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ON THE WAY TO SET COD-NETS.

NEWFOUNDLAND SMACK IN AN ICE FIELD.

DRYING FISH ON A "FLAKE."

ONE OF THE ISLAND FISHERY SETTLEMENTS, SHOWING THE "FLAKES" CONNECTED WITH EACH HOUSE. FOG IS RISING IN THE DISTANCE.

A PILE OF NEWFOUNDLAND CODFISH.

UNLOADING FISH AT ST. JOHNS.

THE NEWFOUNDLAND FISHERIES.

THE COD FISHERIES OF NEWFOUNDLAND.*

By DAY ALLEN WILLEY.

THE signing of the famous Bond-Blaine treaty, by which the market of the United States is partly thrown open to Newfoundland, will allow Americans to become acquainted with the famous codfish upon which the people of the great island depend so extensively for a livelihood. Up to this time, the greater proportion of the catch has gone to Great Britain, the West Indies, and South America; and it may be said that a very large population in the tropics depends upon the Newfoundland cod as a staple article of food, while cargoes have been sent across the Atlantic for centuries. It is an interesting fact that religious ceremonies have had much to do with the development of this industry, the demand for fish in Queen Elizabeth's time being such in both England and in northern Europe that nearly every sea became a fishing ground. In 1563 laws were passed in Great Britain providing that fish must be used in place of flesh or fowl at least 153 days in a year.

A large quantity of the product which was sent to England from Newfoundland in this century was caught by French, Portuguese, and Spaniards, who, as is well known, were the pioneers in the Newfoundland waters. The year 1600, however, found a fleet of about 200 vessels crossing the Atlantic, principally from Devon and other ports of the English west country. Quite a number of these decided to locate upon the island, and the colony owes much of its progress and prosperity to-day to these sturdy fishers.

When it is stated that over half of the population of 220,000 people in Newfoundland gain a livelihood almost entirely from the cod-fishing industry, an idea can be gained of its importance. It is small wonder that the courts of the island have legally applied the term "fish" to cod, owing to its importance; and when one speaks of fish, he is understood to mean the codfish, which, in the northern and southern coast settlements, is so often used as an equivalent of money as to be called Newfoundland "currency." It is measured by the quintal of 112 pounds, and in this form pays for food, clothing, and medicines, as well as fees for physician, the clergyman, and the lawyer. The fish "flakes" are so numerous in all of the towns, and even St. Johns itself, that it would be impossible to guard their contents; so stringent laws have been passed to prevent thieving, and the culprit who is convicted is frequently sentenced to several years in confinement, though he may take but a single fish.

While Newfoundland craft are to be seen in numbers upon the Grand Banks, during the last few years the crews have confined their operations largely to the waters in the vicinity of the island. Although the cod are somewhat smaller, they are fully as numerous and of excellent quality, while, in a good season, fish weighing ten and twelve pounds are frequently caught. The vessels range in size from the schooner, 125 feet in length and over 100 tons burden, to the sailboat manned by two men, who cast their lines or set their nets under the lee of the rocky shores perhaps not more than 500 feet from land, for schools of fish are to be found in proximity to the coast as well as a hundred miles away from it, depending largely upon the course of the Labrador current, which forms their principal food supply. The larger vessels are schooner rigged, and usually carry two jibs, a mainsail, foresail, and main topsail, with sometimes a small jigger extending over the stern, and staysail rigged between the two masts. In addition, they carry a triangular riding sail to assist in steadying them when they are at anchor. The larger ones are manned by from 15 to 30 men, provided with lines for deck fishing as well as set lines and trap nets. Each carries its complement of boats, and, on arriving at a fishing ground, a part of the crew throw their lines over from the deck, while others bait and put out the set lines and the trap nets from the smaller boats, visiting them at regular intervals to gather in the fish, which are taken to the schooner to be hastily cleaned, salted, and packed in the hold until the "fare" is completed. The captain usually keeps his boat anchored as long as the school which has been "struck" remains. The fish may stay on one feeding ground four or five days, or perhaps disappear in four or five hours after the vessel has cast anchor. Then the set lines and nets are taken up, the vessel weighs anchor, and search for another school begins.

In offshore fishing, the trap net is also used in addition to set lines, and the larger boats occasionally use hand lines as well, if the fish bite freely. A very large catch is made, however, with the set lines and nets, and the boatmen go out every morning to take out the fish and bait the hooks, perhaps paying another visit in the evening. Upon the return of the men to the home settlement with their boatload of fish, the women and children join them in cleaning the "fare," salting it and spreading it on the "flakes" to dry. At times the fishing is so good that the men make three and four trips daily to the nets and lines, carrying home a good load on each trip. Then the women and children prepare the fish in order to save time.

The time required to "cure" the codfish varies from four to ten days according to the weather. With a succession of sunny days, the "fare" will be thoroughly cured in less than a week, but the fish must be protected against rainy weather, in spite of the salt with which they are rubbed after being cleaned.

The "flakes" are composed of platforms of tree boughs, elevated from six to ten feet above the ground upon scaffolding; and the fish are laid upon the boughs so closely together, that at a distance the "flakes" look as if they were covered with pieces of white canvas. Each fish is turned over at least once every twenty-four hours, in order to cure both sides thoroughly; and when the process is completed, the fish is as stiff as a piece of board. No other ingredient except salt is required for the ordinary curing, although some of the cod prepared at the larger settlements are ground into fine particles, after being dried, and mixed with a jam made of small berries. This is placed in jars and sold as a preventive for scurvy. The "fares" secured by the larger vessels remain in their holds until the cargo is completed. On arrival at St. Johns, or the home port, the cargoes are sold, in a partly cured condition, to the merchants, who finish the preserving process. In buying the fish from the large vessels, as well as from the fishermen in the settlements about the coast, the cod are valued according to their weight, and generally sorted in three different sizes, the largest bringing a proportionately greater price. The merchant, as he is known in Newfoundland, is the large dealer who exports the fish to the tropics and Europe. He buys both from the fishermen and planters. The latter are a sort of middlemen, and usually have "stations" located at different points along the coast. These stations include general stores containing everything required by the average fisherman. The people in the vicinity can go to the station and exchange their harvest for what they need at home and the outfit required for fishing, and if anything is left to their credit, can obtain its equivalent in money. Many of them, however, are usually in debt to the planter, and, in a good year, the surplus remaining after obtaining their necessities, goes in payment of the debt of a previous season. The planters also buy schooner loads, and many of them own steamers and sailing vessels which make regular trips around the island, carrying the fish purchased by the planter to the general market at St. Johns, or one of the other large towns.

While the number of fish caught varies considerably according to the season, the average catch of this species is from 1,250,000 to 1,500,000 quintals, the value of course depending upon the price. Within the last two or three years the revenue from this source has aggregated about $5,000,000, not counting $300,000 for codfish oil, and a small sum for the oil made from the livers of the codfish to use for medicine. The number of crews engaged in codfishing can only be estimated, owing to the variety of craft and the wide field of their operations. Authorities on the subject, however, estimate that fully 60,000 men are engaged in the fishery each year, and that a fleet of fully 1,000 two-masted vessels hailing from the island alone, ply upon the nearby waters and on the Banks. Practically all of these vessels are home-made, the wood for both hulls and spars being secured from forests in the interior, while the sails and rigging are imported chiefly from England.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

STRANGE FACTS ABOUT THE EUCALYPTUS.

MR. D. E. HUTCHINS, of Cape Colony, who in 1882 in conjunction with Sir A. Brandis discovered the remarkable sun power storage capacity of the eucalyptus, has again been drawing attention in Nature to this extraordinary feature of the tree. According to Mr. Hutchins, a eucalypt plantation in tropical mountains, such as in South Africa, under favorable circumstances, stores up about one per cent of the solar energy received on the unit of area, and it is considered much cheaper in some parts of Cape Colony to plow up the land and plant a forest of quick-growing trees than to import coal.

In 1882 Mr. Hutchins and Sir A. Brandis, as the result of their experiments, discovered that eucalypts planted on tropical mountains produce fuel at the rate of 20 tons—dry weight at 60 pounds per cubic foot—per acre per year in perpetuity. The eucalypt plantation reproduces itself when cut without further expense, and its dry timber, heavier than coal, has an equal or a higher thermal power, bulk for bulk, than coal. This result was obtained as a measurement of the maximum yield of Eucalyptus globulus on the Nilgiris, Southern India. If a chance tree on a chance mountain in a chance soil can produce the equivalent of 20 tons of coal per acre per year, it seems not unreasonable to suppose, Mr. Hutchins suggests, that by selection double this, or 40 tons, can be produced. A powerful sun, a heavy rainfall, and a very rapid forced growth are the essentials of such a production of wood fuel. A glance over the rainfall map of the world shows these conditions are fulfilled over about 8,000,000,000 acres of its surface, which is between one-fourth and one-fifth of the total land surface of 35,200,000,000 acres. One-half of this area under forest might thus yield the equivalent of 160,000,000,000 tons of coal yearly, which is more than 288 times the world's present consumption of coal, assuming that coal and eucalypt timber are of approximately equal heating power. On the basis of the actual forest yield of the present day, we have half of this, or the equivalent of 80,500,000,000 tons. In Germany, one-fourth of the total area is under forest, and taking the German standard of one-fourth forest, on the basis of the present maximum yield we should obtain 40,250,000,000 tons; while if the maximum forest yield be converted to an average forest yield there would still remain a yearly product of 20,175,000,000 tons, which is rather more than thirty times the world's present consumption of coal. Thus it is seen that the yield of firewood from the world's tropical and extra-tropical forests, wherever they are fully stocked and scientifically worked, will yield the equivalent of from 30 to 122 times the present consumption of coal, or even up to 243 times the present consumption, if by cultivation the present timber yield be doubled, as it might be without difficulty.

THE ANCIENT RUINS OF RHODESIA.

THE remarkable ruins in South Africa, which by many are boldly declared to be the remains of King Solomon's mines, are fully described and illustrated in a recent work by R. N. Hall and W. G. Neal. No theories are offered for the presence of the ruins in savage lands. The authors, however, seem to incline to the opinion of Prof. Keane, which is, in brief, that "the 'gold of Ophir' came from Havilah (Rhodesia), and was worked and brought thence first by the Himyarites (Sabæans and Minæans), later by the Phœnicians. . . . The numerous objects of Semitic worship and the fragments of Himyaritic script found at Zimbaye and elsewhere south of the Zambesi leave no reasonable doubt that the old gold-workings and associated monuments of this region are to be ascribed to the ancient Sabæans of South Arabia and their Phœnician successors."

Correspondence.

APPARENT CHANGE OF POSITION OF A TARGET'S BULL'S EYE.

To the Editor of the SCIENTIFIC AMERICAN:

Having read with much interest the communication in your SUPPLEMENT, No. 1419, by Dr. Friedrich W. F. Riehl, treating of the apparent change in position of a target's bull's eye under different conditions of light, it occurred to me to question several old members of the rifle club (*skyttegille*) of this town whether they, all of them good marksmen, had had experiences similar to those of Mr. R. I found that all and every one of them were perfectly cognizant of the fact that with differing lights they had to change their aiming, just according to the calculation put forth by Dr. Riehl. They, however, ascribe it to some disturbing influence of the light on the peepsight, not to any apparent change in position of the bull's eye.

AXEL DANIELSON.

Wisby, Island of Gotland, Baltic Sea, March 27, 1903.

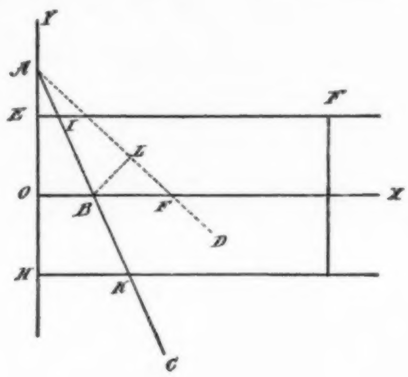
AN EXPLANATION.

To the Editor of the SCIENTIFIC AMERICAN:

The reason for the construction given on page 22537 of the SCIENTIFIC AMERICAN SUPPLEMENT for December 13, 1902, may not be obvious to many, and the argument is here given.

In the accompanying drawing, we fold any trapezoid *EIKH* so that the edge *EH* may pass through the fixed point *F*. The question is to find the envelope of such lines as *IK*.

Produce the edge *EH* indefinitely, as also the perpendicular *FO* upon *EH*, taking *O* for origin of rectangular co-ordinates with axes *OX* and *OY*.



Let $FO = 2p$, $OB = a$, $OA = b$; then

$$\frac{x}{a} + \frac{y}{b} = 1 \ldots . 1 \qquad \frac{x}{2p} + \frac{y}{b} = 1 \ldots . 2$$

are the equations of the lines *AC* and *AFD* respectively.

From *B* draw the perpendicular *BL* to *AFD*. Then $BL = BO = a$.

But also from 2,

$$BL = \frac{2\,bp - ab}{\sqrt{6^2 - 4\,p^2}}$$

(for it is the perpendicular distance from the point a, o to the straight line 2).

Hence, clearing of fractions and rationalizing:

$$a^2\,p = (p - a)\,b^2 \ldots\ldots\ldots\ldots\ldots\ 3$$

$$\text{From 1} \quad b = \frac{ay}{a - x} \ldots\ldots\ldots\ldots\ 4$$

Substituting 4 in 3, and simplifying:

$$p\,a^2 - (2\,p\,x - y^2)\,a + p\,(x^2 - y^2) = 0 \ldots\ldots\ 5$$

But the condition for the envelope of 1 is that 5 have equal roots, or

$$(2\,p\,x - y^2)^2 = 4\,p^2\,(x^2 - y^2) \ldots\ldots\ldots\ 6$$

Expanding 6 and arranging,

$$y^2 = 4\,p\,(x - p) \ldots\ldots\ldots\ldots\ 7$$

Transferring the origin to the middle of *OF*, 7 becomes $y^2 = 4px \ldots 8$, the common parabola, as was assumed.

WILLIAM HOOVER.

Ohio University, Athens, Ohio.

DIELECTRIC CONSTANTS OF CRYSTALS.—W. Schmidt has worked out the method of determining dielectric constants originally described by Drude. It consists in immersing small crystals in liquids of various dielectric constants ranging from 2.3 to 80, and consisting of more or less dilute solutions of benzol in acetone or of acetone in water. The bath is placed between the armatures of a condenser at the end of a Lecher wire system, and when the liquid has the same dielectric constant as the solid, the immersion of the latter causes no alteration in the position of maximum resonance. The author has made this method available for crystals of a high dielectric constant by making the secondary circuit resound to the primary circuit underneath it, thus practically employing the method used by Drude for the determination of inductances. Maxwell's rule $k = n^2$ is only fulfilled in sulphur. In the other crystals examined there is no numerical agreement whatever, and mostly no qualitative agreement either. In some crystals, like pyromorphite, rutile and aragonite, the "electric double refraction" or difference of dielectric constant in different directions may be as high as 50 per cent. Rutile and pyromorphite also show a surprisingly high dielectric constant considering their low conductivity. In beryllium and tourmaline the dielectric constant is much greater at low frequencies than it is at high frequencies.—W. Schmidt, Ann. der Physik, No. 12, 1902.

AN INTERESTING COLLECTION OF CAMBODIAN RELICS.

HEINRICH THOMANN, whose collection of casts, prints, frescoes, and photographs from Pagan, described in The Tribune recently, are now on exhibition at the American Museum of Natural History, brought with him also a Cambodian collection, which is of equal importance. This consists of objects somewhat similar to those in the Pagan collection, but they all point to the fact that the architecture which they represent was of a higher order and more original than that which was employed in beautifying the plains of Pagan.

The kingdom of Cambodia, south of Siam and northwest of French Cochin China, has an area of 40,530 square miles and a population of about 1,500,000. It has been under French protection since 1863. Its largest town, Puom-Peuh, has a population of about 50,000, and its "seaport," Kampot, is not accessible for sea-going vessels. Rice, tobacco, indigo, spices and coffee are the chief articles of trade, and these are sent to the markets of the world by way of Cochin China.

Although commerce has not attracted many visitors, its antiquities have induced students to make extended tours through the country, and they have been rewarded by many valuable discoveries. Mr. Thomann is among the most industrious of these, and his collection is the result of years of careful search and industrious study.

"Of all the Khmer ruins," he said, "in the kingdom of Cambodia, the most important and wonderful are those of the great city Angkor-Thom, situated in 103.50 east longitude and 13.30 north latitude, within five miles of that great monumental structure, the Brahmin temple Angkor-Wat. I look upon this great pile as one of the most wonderful architectural relics of its time. It was begun under King Bautomo Saurivong, who lived in the ninth century. It consists of three great galleries, one above the other, eighteen and twenty-five feet apart. These galleries, or colonnades, are not on the same line when viewed on the outside, but one back of the other, giving the temple a pyramidal form. The first, or lower, colonnade is 520 feet long and 670 feet deep. The inner walls of this gallery are covered with bass-reliefs to the height of six feet. The stone slabs, eighteen inches thick, are so nicely fitted without mortar or cement that the joints can be detected with difficulty.

"The second gallery, which is supported on carved pillars, has about twelve thousand square feet of bass-reliefs, showing about twenty-eight thousand men, women, animals, and celestial beings. At the sides of the main entrance and on one side, the reliefs represent religious scenes, and on one side the raging sea is represented with the great Snake Nagga. These reliefs demonstrate the fact that the great edifice was erected by snake worshipers, and that the Buddhistic ornaments which it now contains were taken there after it became a Buddhist temple.

"On the south side the carvings represent the three worlds, earth, heaven, and hell, and one side shows the king who built the temple, with a great following of generals and warriors of many types. The sanctum of the temple, the central tower of the three colonnades, one within the other, rises to a height of 180 feet, and this feature gives the monument its imposing appearance."

Mr. Thomann's photographs of the temple are of a high order, but the important part of the collection consists of the reproduction of the delicate carvings and bas-reliefs. Of these there are several hundred square yards. There are also casts and paper facsimiles of the carvings in the ruins of Angkor-Thom and Bayon, which were built in the fourth century.

Dr. Boaz, of the American Museum of Natural History, in whose department these casts and photographs are on exhibition, said that they were of great value to the student of ancient art, and he hoped that they would find a permanent resting place in one of New York's educational institutions.

William S. Kahnweiler, who visited Angkor-Wat, says of the place:

"Most places of renown that one has heard and read much of produce a sense of disappointment on being visited. The Angkor-Wat is one of the notable exceptions to this rule, at least, so I found it. Situated in the heart of a country where architecture in stone is otherwise unknown, and where, in consequence, all vestiges of the earlier surrounding races have disappeared, the Khmer people have left in the Angkor-Wat, the Angkor-Thom, and other less important ruins in the surrounding country, undying monuments to their greatness. This isolation undoubtedly adds much to the effect they produce upon the mind, but even without this aid, and placed in any other country, these ruins would impress by the vastness of their dimensions, by the scope of the ground plan and general scheme, by the solidity of structure, the wealth of decorations and the beauty and delicacy of execution.

"Nothing finer or more impressive can be imagined than the great avenue of approach; or anything more immense than the first outer cloistered quadrangle with a great gate in each wing high enough to admit the elephants and wide enough for entering chariots.

"Passing through this the impression is heightened by the great proportions of the inclosed space, and the length of the second procession path leading up to the terrace, from which springs the main structure, a triple temple, presenting three of its tall, domelike towers at the front. This entered, one wonder crowds upon and surpasses the other—the delicately chiseled pilasters of classic pattern at the portals; the excellently preserved carvings on pillar and wall, wherein the whole Indian pantheon is recognizable; the beautifully molded window bars; the endless cloisters with their zones of bas-reliefs telling the oft-repeated story of the Ramayana or presenting scenes of heaven, earth and hell, those of earth incidentally giving us interesting pictures of the daily life of the people; the numerous niches now appropriated by figures of the Buddha and his disciples; the effect of constantly rising as one passes from the outer through the central to the innermost temple; the four elaborately carved inner courts in cruciform arrangement, and the massive central dome—the great climax—towering far above. All these produce a tremendous impression, as of an heroic work, broadly conceived, mightily planned and lovingly executed—vast yet homogeneous, grand in conception, yet with no detail forgotten or labor spared."—New York Tribune.

A PLAGUE OF MOVING ISLANDS.

NEARLY a month ago a crevasse occurred at Hymelia, thirty-seven miles above New Orleans on the west bank of the Mississippi. It is not yet closed although $150,000 has been expended on the work, and the waters of the Mississippi are pouring in at the rate of hundreds of millions of gallons a day.

The railroads and planters of the neighborhood have managed to minimize the damage by side levees and embankments. Thus the Texas & Pacific Railroad has raised and ballasted its track, and is running trains through the very heart of the crevasse. The sugar planters have built levees so as to keep the flood off their plantations and empty it into the great Des Allemands Swamp which, with its network of lakes and bayous, stretches down to the Gulf of Mexico, a distance of 150 miles.

This country has been free from overflow for more than a decade, and pioneers have recently penetrated into the swamp and begun cultivating the highlands, these rising as much as from two to four feet above tide-water. The lumbermen, loggers, fishermen, and swampers engaged in killing alligators and gathering Spanish moss, usually live in houses built on piles above the water. There are several prosperous settlements in the swamps, where stock, eggs, and chickens and vegetables are raised for the city market.

This is all a novelty. Previous to 1893, when the levee system was rendered safe in this part of the State, the swamp was little known, except to hunters, fishermen, and loggers, and there were practically no farms within its entire area.

Visitors of twelve or fifteen years ago told of the picturesque floating islands to be found in some of the lakes of the swamp—Des Allemands, Ouacha, Salvador, and others. These islands scudded before the breeze like so many ships. They have not been seen for years, but the Hymelia crevasse, pouring its oceans of water into the swamp, has not only moved the floating islands, but multiplied them ten-fold, to the great confusion of the inhabitants and the inconvenience of the railroads.

Most of the swamp is what the Creole swampers call *prairies tremblantes* (trembling prairies). It is land but floating land, built up over the water by the accumulation of centuries, of logs, branches, leaves, and vegetable mold. It is light enough to float, but strong enough to support men and even cattle. It trembles when walked on.

The earth is held together by the inter-twining branches of the plants or trees, for frequently very large trees grow on these trembling prairies. Occasionally some of the land is torn away and becomes an island. Such islands are known as *flottants* or floaters, by the Creoles, and are among the most picturesque sights of these Louisiana lakes, sailing upon them, borne hither and thither by the winds or currents.

In old days, there were dozens of these floating islands, some of them acres in extent. This year the rush of the Mississippi through the Hymelia crevasse has torn up the trembling prairies, and created floating islands by hundreds.

They are to be found in all the many lakes and bayous of that region, and are most confusing to visitors and even natives. The landscape changes, not every day, but every hour, and the land and forest shifts from one side of the river, bayou, or lake to the other in a night.

The natural tendency of the islands is to drift toward the Gulf, and when the Hymelia crevasse begins to empty its full force into the Gulf of Mexico, ship captains navigating that body of water are likely to be confused by discovering new lands and tropical islands where the charts show none.

For the present, however, the *flottants* are proving most troublesome to the railroads by threatening their bridges. So many islands have floated down Bayou Des Allemands as to endanger the big bridge of the Southern Pacific over that stream.

The railroad company has a large force of men near the bridge. They have driven piles and built up a network above it to catch the floating islands, which are blown up, cut up or otherwise destroyed, so as to prevent them from floating against the bridge and wrecking it.

The soil is found to be from six to eight feet deep, with the intricate entanglements of vines, grasses, and trees, and the islands are very picturesque. They would be handsome ornaments in a pleasure lake, and they are attractive even in the Louisiana swamps, but the railroads and the settlers there say that they are a nuisance, as they frequently run aground in the network of smaller bayous, act as a dam in the stream, and help to overflow the neighboring lands, even when they do not carry away the railroad bridges.—New York Sun.

NOVA PERSEI.

SCIENCE contains a paper by W. W. Campbell, Director of the Lick Observatory, on the co-operation of astronomers in the use of their instruments of research. The following paragraphs relate to recent investigations of the new star in Perseus:

"Perhaps the most interesting astronomical events of recent years relate to the new star in Perseus, discovered in Edinburgh on February 22, 1901. The Lick Observatory, in common with all similar institutions, made immediate plans to bring every available resource to bear upon the study of this star. Its position was measured by Mr. Tucker with the meridian circle, and by Mr. Aitken with the thirty-six-inch equatorial on several occasions in the spring and summer of 1901. It is clear from these observations, amply confirmed by those made elsewhere, that the new star is at least as far away as the faint stars surrounding it, and that its motion with reference to the surrounding stars is so slight as to elude detection for the present. The spectroscopic observations by Messrs. Campbell, Wright, Reese, and Stebbins were extremely fruitful in results.

"A photograph by Wolf, of Heidelberg, on August 23, 1901, had led to the discovery of masses of nebulosity in the vicinity of the new star. A photograph by Ritchey, of the Yerkes Observatory, on September 20, confirmed and extended the discovery, showing that the new star was apparently situated in a nebulous mass nearly circular in form and of great extent. The photograph of this region made by Mr. Perrine with the Crossley reflector on November 7 and 8, when compared with Ritchey's published photographs of September 20, led to the extraordinary discovery that the well defined nuclei in the nebula were apparently in rapid motion; the magnitude of the apparent motion being at least seventy-five times as great as any sidereal motion previously known. Telegraphic announcement of this discovery was made at once, and intense interest was taken in the subject. A photograph made by Ritchey at the Yerkes Observatory on November 9 afforded full and independent confirmation of Mr. Perrine's remarkable discovery. Photographs made at intervals throughout the winter have enabled us to follow the motions of the brighter masses.

"Later examination of our early photographs of this region by Mr. Perrine in January, 1902, led to the discovery that two rings of nebulosity surrounding the new star were beautifully recorded on the plate of March 29. We were thus able to extend the history of the phenomenon backward five months.

"The consensus of opinion is that the new star is the result of a violent collision between two dark stars, or between a dark star and a nebula. It can easily be shown that the kinetic energy of two such bodies, approaching and colliding with enormous relative speed, would be converted into heat in sufficient quantities to transform the dark bodies into incandescent gases. The history of previous new stars had led us to expect that the spectrum would gradually change into that of a nebula, and in this we were not disappointed. For a suitable study of the present nebular spectrum of the new star, it was necessary that further and more accurate investigations be made upon the spectra of the well-known nebulæ. These investigations were undertaken with great success by Assistant Astronomer Wright. He determined the positions of many well-known nebular lines more accurately than had previously been done, and a number of very interesting new lines were detected."

EXPLORING A RIVER.

MORE than twenty years ago Savorgnan de Brazza carried a little steam launch overland between the headwaters of the large Ogowe River and the upper part of a river on the other side of the divide, a few miles away. The natives called this stream the Alima, and De Brazza believed it was a tributary of the Congo and that he might steam down the Alima to the upper Congo far above Stanley Pool.

His experiment was a great success. He descended the Alima about 400 miles and finally entered the Congo where the great river is several miles in width. Then he floated down that river to Stanley Pool.

Meanwhile, Stanley had been laboriously ascending the Congo, dragging his supplies around 235 miles of rapids; and when he reached Stanley Pool he was much surprised to find the French flag floating on its northern bank. De Brazza had arrived before him and was founding the station of Brazzaville.

Ever since that day a large white space has existed on the map between the Alima and the Congo. Explorers were too busy elsewhere to trace the rivers in that region. At last the Pama River, supposed to be the largest tributary of the Alima, has been partly explored, and a portion of the blank space on the map has been filled.

Capt. Scheerlinck, agent of the Commercial and Agricultural Society of the Alima, has ascended its Pama tributary for a distance of about 80 miles. The upper part of the river has also been explored, but no one has visited the middle portion.

The river is about 200 miles in length, and Capt. Scheerlinck found that for a part of the way it flows through a wooded region in which are numerous herds of elephants and buffaloes. The country is not densely peopled, but there are a number of large settlements on its banks, where white trading stations have been established.

It was near the place where the Pama joins the Alima that De Brazza found a native chief, whom he attempted to use to further his political schemes in behalf of France. This story is a good illustration of the tricks to which explorers sometimes resort when they are scrambling for all the territory they can seize.

De Brazza announced that on the Alima was the capital of the great King Makoko, a direct descendant of the ancient kings of the large native State of Congo, south of the river of that name, and in Portuguese territory. This sovereign, he declared, was the ruler of all the country between the Alima and the Congo and of both banks of the Congo between Stanley Pool and the mouth of the Alima.

He signed a treaty with this great king, who placed his entire territory under the sovereignty of France. The treaty was seriously discussed and approved in the French Chamber of Deputies; but, after all, France never came into the possession of both banks of the upper Congo.

It was conclusively shown in a few months that the "great King Makoko" was nothing but a poor little Bateke chief, with only a few hundred followers and a very small territory. He had no influence whatever outside of his small domain. When the real facts were made known, nothing more was said about the famous Makoko, and the French gave up all claim to the territory on the left bank of the Congo.—New York Sun.

IT is often difficult to make the color stick to a photograph, both in retouching and coloring. A simple method is to pass a piece of freshly-cut potato over the surface of the image; the color sticks immediately to the parts thus treated.—Drug. Circ.

MECHANICAL TRACTION ON TRAMWAYS.

THE number of tramways upon which mechanical traction was employed, and that were in operation in France at the close of 1901, was over 3,000. The systems most generally employed are (1) the electrical, with overhead conductor, in the densely populated suburbs and cities of average size in which this system is authorized, and (2) traction by steam locomotives on vicinal lines and on a few lines that connect neighboring mining or metallurgical localities. In certain cases, however, these two systems give rise to objections. The multiplicity of the conditions—municipal, technical, or financial—to be satisfied has sometimes led to the adoption, according to the district, of the most diverse methods of traction. We shall examine here only the Rowan and Purrey steam systems and the Mekarski compressed air system.

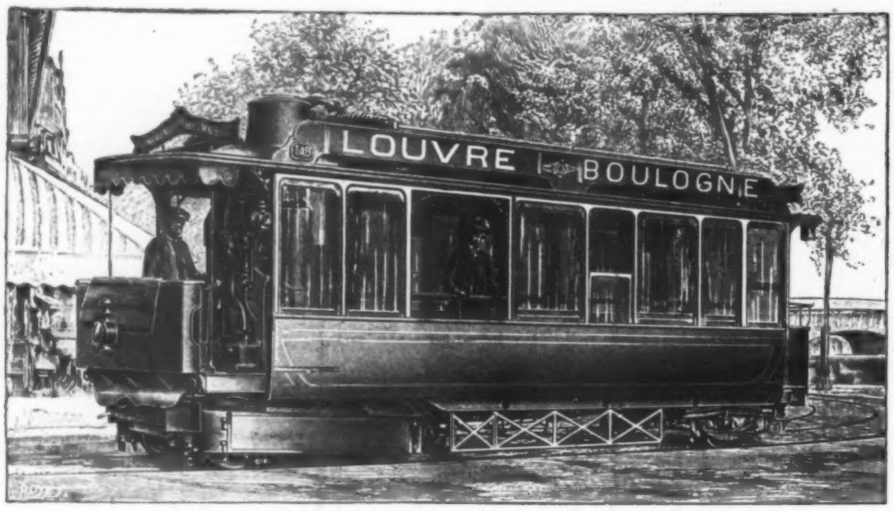


FIG. 1.—GENERAL VIEW OF A ROWAN STEAM MOTOR CAR.

The Rowan steam car (Fig. 1) is characterized by the following arrangements: The motor is placed upon a special truck, which is interposed between the longitudinal members of the car-body, like a horse between the shafts of an ordinary vehicle, so that when it happens to need repairs it can be quickly replaced by a duplicate truck. This obviates the necessity of having as many car bodies as motors. The front of the body rests upon the truck without rigid connection (with the result that the adhesion is thereby increased), and in such a way that the latter can swing around freely upon curves, and, at the same time, allow the axle that supports the rear end of the body to take a position in line with the radius of the curve. Sharp curves are thus taken without difficulty, despite the long wheel base of the car, which assures the body a firm support along with a very easy suspension. The boiler, which is upright and multitubular, is of high power, and occupies but slight floor space. The engineer has every convenience for feeding the furnace and having an eye to the supply of the boiler and to the mechanism. As the latter is easily accessible, the lubrication and keeping in order are thereby greatly facilitated. The steam, after acting upon the pistons, goes to an air condenser upon the roof of the car (of the same length and width as the latter) and becomes entirely condensed therein. Since the fuel employed is coke, and neither smoke nor steam is emitted into the atmosphere, the motor is well adapted for use on city railways. The water of condensation, collected in a tank arranged beneath the floor of the car, is employed for feeding the generator. From this arrangement two advantages are obtained: (1) An increase in the economic efficiency and the power, from the use of hot feed water, and (2) the prevention of a deposit of scale upon the plates and tubes. The boiler is arranged in the center of the truck, to which it is secured by a flange and bolts. The external jacket is cylindrical, as is also the furnace, which is surrounded by a square box, the opposite sides of which serve as tube plates. The tubes, 131 in number, are arranged in alternate rows, as shown in Fig. 2, and are screwed into the plates in an inclined direction in order to facilitate the disengagement of the steam. Their internal diameter is 1.1 inches, their thickness .196 inch, and their length 22.8 inches. They may be mounted quincuncially or in vertical rows. Although the latter arrangement does not absorb quite so much heat from the fuel, it facilitates the draft as well as the cleaning of the exterior cells of the tubes.

The total capacity of the boiler is 169 gallons, and the volume of water, at the normal level, 105 gallons.

The boiler jacket is formed of two parts bolted together. The lower part is riveted to the iron plate of the furnace and is stationary, while the upper part is movable, so that the lower plates may be exposed in order to clean the walls or to replace some of the tubes.

The working pressure of the boiler is 30.8 pounds, but such pressure is never employed in the cylinders. The grate surface is nearly 700 square inches, the heating surface of the furnace is 17.5 square feet, and that of the tubes 95 square feet. On making use of the blast or the exhaust, the production of steam per hour may reach 28¼ cubic feet, which corresponds to 44 pounds per horse power at its normal output of 40 horse power.

The feed is assured by a pump and injector. The motor truck carries a 25-gallon reservoir, which, by means of movable rubber couplings, is connected with tanks of 125 gallons capacity arranged beneath the car. Two of these tanks receive the water derived from the condensation of the exhaust steam, and are utilized for feeding with the pump, which may be done with water at a temperature bordering upon 100 deg. C., if care be taken to place the pump under head. A third tank filled with purified cold water is used for feeding the injector at stations. Under such circumstances, the plates of the furnace and the tubes may be kept clean for a long time if a partial blowing off be effected every night after the car has been housed, and a total blowing off at the biennial stoppage of the motor for general inspection. An annual cleaning will then suffice to assure the general state of efficiency of the motor.

It is easy to understand that feeding with water at 90 deg. C. gives, as compared with feeding with water at 10 deg., an increase in the efficiency and power of the generator of more than 20 per cent. The furnace is fed by means of long and narrow cylindrical funnels. The engineer makes a very hot fire at the ends of the line so that he may not have to stoke it along the route. He can then devote his attention constantly to the track and avoid accidents. He regulates the pressure by the degree of opening of the draft and blower. The cylinders are placed horizontally upon the platform of the truck, and their pistons actuate the axles through the intermedium of side-levers. This, which is what is called the Winterthur arrangement, has the advantage of protecting the mechanism in great part from dust and mud and rendering the surveillance along the route much easier. The diameter of the pistons is 5½ inches and their stroke 13½. With a wheel diameter of 24¾ inches, the theoretic traction force reaches 4,650 pounds, while the practical force utilized rarely exceeds 2,200.

The valve system of the engine is different from that usually employed, there being slides, but no eccentrics. The direction of running is changed by means of a lever situated at the right of the engineer, while the handle of the throttle is arranged at his left. Since the brake is controlled by a pedal, he has thus every convenience for promptly starting, stopping, slowing down, or resuming speed as desired.

The condenser is formed of brass tubes made by riveting in pairs thin plates shaped in a matrix. These elements are afterward brazed to bronze mountings which are screwed to a cast iron collector that receives the exhaust steam of the motor. The length of the condenser is 19.6 feet, its height 12 inches, and the surface exposed to the air 860 square feet. When the tubes are clean internally and externally, the exhaust steam is wholly condensed, if the motor is in a proper state of repair, and the output of steam relatively small. If for any cause whatever, the condensation is not perfect, a pipe extending from the condenser to the smoke stack permits of a flow of the steam in excess, and thus prevents the counter pressure upon the pistons from becoming excessive. The lubricating of the cylinder must be done with oil of good quality, in order that as little of it may be used as possible, so as to prevent the oil carried along with the exhaust steam from coating the walls of the condenser, of which it would thus diminish the efficiency. It will be seen that such a condition can be observed here, because, when running with throttle closed, the cylinders are lubricated by the steam aspired by the pistons through the condenser. In motors in which the exhaust steam escapes into the smoke stack there is produced, on the contrary, while running under similar conditions, a suction of hot gas and ashes which heats and tends to scratch the cylinders, and afterward necessitates the forcing, to a certain extent, of the lubrication of these parts.

The car-body comprises three compartments. The one first behind the motor is set apart, on suburban lines, for merchandise and baggage, but on city lines is arranged to accommodate 10 passengers—six seated and four standing. In this case it is open at the sides. The middle compartment, which is entirely closed, is provided at the sides with seats that extend the entire length of the car. It is spacious and well lighted and affords seating capacity for 20 passengers. Finally, the rear part, forming a platform, is capable of accommodating 11 persons. The body is mounted upon the motor-truck in front on two reversed semi-elliptic springs suitably hung on shoes that move in circular flange guides secured to the truck frame. It is drawn along by the latter by means of two strong iron plates set edgeways between two rollers arranged at the front of the truck. At the rear, it is supported by a frame with a single pivoting axle, the angular displacements of which are regulated by the motor truck itself by means of two rods jointed, on one hand, to the two sides of the frame, and, on the other, to the rear corners and opposite side of the truck. As soon as the latter begins to round a curve, it holds the rear axle in its normal position with regard to the track, and the car is thus able to take curves having a radius as short as 65 feet.

The weight of the car in running order without passengers, is 12 tons.

With their long wheel-base and their excellent suspension, these cars run very smoothly, and on this account, are very highly appreciated by the public. The temperature of the middle compartment in the summer is slightly elevated in consequence of the heat radiated upon the roof by the condenser; but this may be remedied by a proper ventilation, or by causing the motor to operate by free exhaust in the hottest hours of the day, the steam mixed with the gases of combustion then escaping in an invisible manner. On the contrary, in winter, this compartment is very efficiently and economically heated by means of the water derived from the condensation of the exhaust steam, which is made to circulate in pipes arranged under the seats, previous to its being collected in the tanks. Finally, when properly run, these cars perform excellent service. Their consumption of oil is very slight, as we have seen, and as for that of coke, that may fall to 3¼ pounds an hour when the car is running alone, or to 4 when it is hauling a trailer.

FIG. 2.—STEAM BOGIE FOR THE ROWAN MOTOR CAR.—SECTION OF THE BOILER.

There are several cases to which this system of traction is particularly well adapted, viz., to suburban lines of some length on which cars are run every two or three hours, and to a busier service in cities where the duration of the tramway concession is short and the traffic is not sufficient to permit of the use of the compressed air or electric system. The cars are generally powerful enough to haul one, and even two light trailers, and this on busy days or during rush hours would permit of doubling or trebling the traffic.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.

THE STENODACTYL, OR STENOGRAPHIC MACHINE.

WRITING machines have already shown their superiority in cases where it seemed as if the work of man had no competition. Between the mind that conceives and the hand that writes in this operation of transcribing ideas, it seemed as if any mechanical intervention were impossible. The typewriting machine destroyed such prejudices, and plainly demonstrated the pre-eminence of mechanical writing. The stenographic machine had soon to follow, and finally we have it. It took some time to solve the problem, at least as completely as it is done in the Lafaurie "Stenodactyl," an apparatus which far surpasses all its predecessors, and which we illustrate herewith. This machine is provided with ten keys for the ten fingers of the hands. Its arrangement is such that the fingers are placed naturally upon the keys at the point where the latter are to be struck.

The combinations producible by the five fingers of one hand, put 31 different combinations at the operator's disposal. The left hand writes the consonants, and the right hand the vowels. The two hands strike the keyboard simultaneously. The 31 combinations of consonants and the 31 of vowels, diversely juxtaposed, give a number of syllables sufficient to permit of phonetically registering all serviceable sounds.

In this simultaneousness of writing is found the possibility of an integral phonetic reproduction of speech with a very limited number of combinations. By restricting the number of these and fixing their form, the apparatus facilitates the work of the pupil and prevents arbitrariness, which is the defective basis of all the manuscript methods.

The mechanism of the stenodactyl is extremely simple. To every action of the finger upon one or more keys there correspond three successive effects, viz.: (1) Winding and unwinding of the paper; (2) inking of the type; and (3) impression upon the paper ribbon.

As the same fingers always strike the same keys, the former are numbered like the latter, starting with the thumb. To the left: 5, 4, 3, 2, 1; to the right, 1, 2, 3, 4, 5.

The complete combination given above represents the impression of the ten keys struck simultaneously.

The combinations of the figures found in the alphabet represent simply, for the articulation and corresponding sound, the fingers and the keys that serve to write them; and every horizontal line upon the tape corresponds to an entire syllable, which, as usual, is read from left to right.

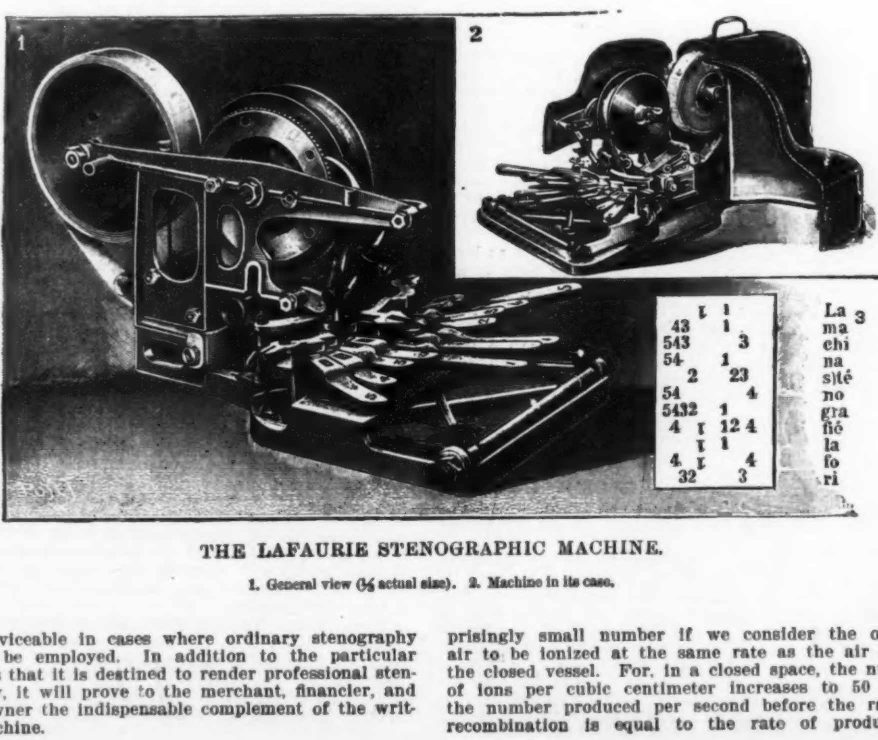
The writing is strictly phonetic. The pupil tries to find, in each syllable, what are the articulations (consonants) and sounds (vowels) that have struck his ear, and endeavors to reproduce them simultaneously by means of the combinations of his fingers, corresponding, in the alphabet, to the vowels and consonants that he wishes to write, without paying any attention to orthography.

As regards speed, the stenodactyl exceeds all the requirements of stenography. It prints a syllable, that is to say, three letters, while the typewriting machine is printing but one. No attention is paid to orthography or punctuation. An operator who inscribes 70 dictated words upon a typewriting machine can write more than 200 upon the stenodactyl.

The logical grouping of the combinations of the fingers in the Lafaurie alphabet greatly facilitates the study of it. It is possible to read perfectly at the end of a few hours, and the first experiments in writing have given a speed of 150 words a minute, after four months' practice of about an hour a day.

By raising the average number of words written in commercial stenography from 100 to 150, the apparatus multiplies the applications of rapid writing; and, by assuring a division of the work between writing and reading, it effects a great saving in time in the operations of stenography. The applications of the machine will therefore be manifold. It must be noted, further, that the machine, which is light and occupies but little space, may be carried without trouble and may be operated in the dark. So it will be capable of becoming serviceable in cases where ordinary stenography cannot be employed. In addition to the particular services that it is destined to render professional stenography, it will prove to the merchant, financier, and shop owner the indispensable complement of the writing machine.

The press will utilize it in all its services; and the use of it in telephone offices will give copies of the messages exchanged, and this will facilitate the employment of it in communications between railway stations. It may be usefully employed, too, by the blind, who will find in it a practical utilization of their remarkable faculties of hearing and touch.—Translated from La Nature for the SCIENTIFIC AMERICAN SUPPLEMENT.



THE LAFAURIE STENOGRAPHIC MACHINE.

1. General view (¼ actual size). 2. Machine in its case.

NON-SKIDDER FOR AUTOMOBILE TIRES.

AN ingenious device has been designed in England for the prevention of side slip, or skidding, of the wheels of automobiles. Two flexible, wire hoops are placed on each side of the wheel, and are of slightly larger diameter than the latter, so as to project a little way above the rim of the wheel. Small steel chains are then passed from one hoop to the other, over the tire, diagonally. The hoop attached to the inner side of the wheel is endless, but that on the outer side is fitted with a right and left hand screw, which enables the non-skidder to be readily and easily adjusted to the tire. The device, however, is so fitted that the diagonal chains do not press tightly upon the tire, but have a little movement. The effect of this arrangement is that when the car is running, the chains creep slightly, and do not impress upon the same part of the tire at any two consecutive revolutions, so that no damage is caused to the tire by the chains. In the cars equipped with this device, only the back wheels have been so fitted, and even when the brake was applied violently and suddenly, the car was always pulled up quickly in its straight course, testifying that the non-skidders do not interfere with the braking action in any way. This contrivance was first attempted upon the bicycle, and was so successful that it has been adapted to automobiles, and prolonged experiments have proved that it is a most efficient nonskidder.

TIRE BOUND WITH CHAIN TO PREVENT CAR FROM SKIDDING.

ATMOSPHERIC IONIZATION.—Experiments have shown that a well-insulated charged conductor placed inside a closed vessel gradually loses its charge, and that this loss of charge is due to a small spontaneous ionization of the volume of air inside the closed vessel, about 19 ions per cubic centimeter being produced in the air per second. E. Rutherford and S. J. Allen have studied this spontaneous ionization, and found that the number of ions per cubic centimeter may be anything from about 13 to 40, but is often identical to the above number 19, representing the number produced *per second* in a closed vessel. This is a surprisingly small number if we consider the outside air to be ionized at the same rate as the air inside the closed vessel. For, in a closed space, the number of ions per cubic centimeter increases to 50 times the number produced per second before the rate of recombination is equal to the rate of production. After making due allowance for the causes tending to remove the ions, such as dust and an electric field, the number is far lower than could be expected. It is possible that the spontaneous ionization of the air observed in closed vessels may be due (in part at least) to a radiation continuously emitted from the walls of the vessel. The spontaneous ionization of the outside air may, on this view, be much smaller than that observed in closed vessels, and the number of ions correspondingly less.—Rutherford and Allen, Phil. Mag., December, 1902.

HISTORY OF PERSONAL JEWELRY.*

By CYRIL DAVENPORT, F.S.A.

THE diamond alone among precious stones is composed of pure crystallized carbon, and is in all probability of direct vegetable origin. This view has been upheld by many eminent men of science, among others by Sir Isaac Newton and Sir David Brewster. The probable sequence of formation is supposed to be—forest tree, turf, lignite, coal, cannel coal, jet, black marble; then certain conditions of heat and pressure under the influences of which the crystallization takes place. Experimentally, films of diamond have been produced by inclosing a block of pure carbon within an iron cylinder, in which it could not expand, and then sending through it a strong electric current. But as far as experimentalists in this direction have yet gone, it appears that to make a crystal of diamond of any useful size would be so costly a proceeding that it would not be worth the trouble and expense.

The natural crystalline form of a diamond is octahedral—like two pyramids joined at their bases—and halves of crystals of this form, polished and set points uppermost, were largely used during the sixteenth century in Europe for setting in rings for the purpose of writing upon glass. Irregularly shaped stones can usually be reduced to the simple form by skillful cleavage, and all well-cut diamonds are made from stones which have so been chipped into the form of a double pyramid.

It is said that Louis de Berghem, of Bruges, found out accidentally, in the fifteenth century, that two diamonds rubbed against each other would in time become polished where the friction had taken place, and from this standpoint he further proceeded actually to cut diamonds with facets, by attrition against each other.

There is, however, little doubt that the superficial cutting of diamonds into facets was known in India long before the time of Berghem. In 1665, the traveler, Tavernier, found that the art of diamond-cutting was fully established there, but if the stones were naturally clear and well-shaped, they were frequently only polished on their natural surfaces, and not chipped, shaped, or faceted at all. If flawed, however, the defective part was freely removed.

The finest Indian diamonds come from Visapur or Golconda, and we also get them now from Borneo, Brazil, Sumatra, the mines of Antioquia, Colombia, Siberia, California, and the Cape.

Most of the forms of cut diamonds can easily be seen to be based upon the original double pyramidal form of the crystal; some of them in the single pyramidal form, which is really only the other cut in two. The upper and lower apices being ground down, gives the "table" form, long highly esteemed. An imperfect crystal, with only one apex and a flat base, being ground down as to its apex, forms what was called a "lasque."

The Indian fashion of cutting an irregularly-shaped stone all over with small facets, was no doubt the original of the "rose" cutting, which is the same thing, only more carefully measured and executed. The rose was a favorite form in Europe during the seventeenth century and after, and it was very likely first used by Italian or Dutch lapidaries. The true "Dutch rose" has twenty-four facets; the base of a rose is flat—it is really a half-crystal.

Toward the end of the seventeenth century, Vicenzio Peruzzi, of Venice, is said to have invented the "brilliant" form of cutting. Cardinal Mazarin is also supposed to have helped to establish the new cutting by his patronage, and dissatisfaction with existing forms. From 1641 to 1653, Cardinal Mazarin interested himself much in the cutting of diamonds, thinking that more brilliancy could be procured by some other methods of faceting than those of the table and rose forms then in use. He eventually induced a lapidary to try a new arrangement called "taille en seize," which is said to have been more effective than anything yet done, and twelve stones were cut in this manner for the French crown—these were called "The Twelve Mazarins."

A true brilliant, as finally determined, should have 32 facets above, and 24 below the girdle of the stone—56 facets in all. The upper surface still retains the name of the table, and all the other facets and parts of the stone are named. The stones are first chipped into shape, as nearly as possible, the crystal of diamond being easily flaked off in the direction of its natural faces, and then ground and polished laboriously with oil and diamond dust.

The weight of diamonds is often much diminished by cutting. The weight is calculated by "carats," a word derived from κεράτιον, meaning the seed of a small vetch. These seeds are remarkably uniform in weight, being about 3¾ grains Troy, but, of course, now they are not actually used, as they once undoubtedly were.

In the eighteenth century, cut diamonds were often backed with a black varnish, made of mastic and ivory black, or sometimes with black silk. The transparent setting of stones is quite a modern innovation. It is always difficult to judge the true color of any backed stone. Varnished diamonds used to be kept in water at night, so as to preserve the varnish.

Diamonds have not often been cut as signets, because of the extreme technical difficulty and tediousness of the operation. It is not, however, unknown. I have seen one bearing a profile portrait of Queen

* A paper read before the Society of Arts.

Victoria, and at Windsor is the yellow diamond signet of Charles II., engraved with the ostrich plumes of the Prince of Wales.

Diamonds are now and then beautifully colored, a yellow tinge is perhaps commonest, then pink, then blue. The finest blue diamond is that known as the "Hope." It is like a fine sapphire, with brilliant prismatic play of light, and is set as a brooch, within a border of white diamonds. It is supposed, like the Koh-i-Noor, to be a fragment of a larger stone. Black diamonds are only curious, and bort, a formless mass more or less gray or dark in color, and of no ornamental use, is diamond in an abortive form, and is crushed into powder to polish other diamonds with. A green diamond is a great rarity; I have never seen one.

Colored stones belong to one or other of the remaining two great classes of jewels, those having alumina as a base, or those having silica as a base. To the first group belong all the harder stones known as corundum; in this group are included rubies, sapphires, emeralds, as well as the stones described with the prefix "Oriental," all of which are very hard. The coloring matter is approximately the same in stones as well as in glass enamels, and roughly, the reds are caused by oxide of iron, and greens and yellows by chromic oxide. There are many other coloring oxides, but these are the most usual, and a very small proportion of them will give a very rich coloring.

The stones with the base silica include all quartzes, beginning with rock crystal. This clear crystal when stained by the infiltration of one or other of the metallic oxides, becomes more or less intense in color, and differently colored stones are known by different names, amethyst, aquamarine, topaz, peridot, tourmaline (a stone assuming many colors and remarkable for its curious optical qualities), garnet, spinel, cat's eye, and numbers of others. In this class also come the numerous agates and onyx.

Opal is a vitreous stone full of small fissures, the surfaces of which are striated with microscopic lines which break up the normal white ray into its colored parts, and thereby give the impression of color. The opal is very soft, and soon loses its polish, and the iridescence is quite destroyed by grease. Damp will destroy the iridescence temporarily, but it can in this case be restored by warming the stone before a fire. The fire-opal is a deep orange stone of great beauty.

Colored stones, until the period of the Renaissance, were used in jewelry much in their natural shapes, but superficially polished. This is called "cabochon." As lapidaries became more skillful the stones were given more accurately oval forms; and about the fifteenth century they were first cut and faceted in Europe, as they generally are now. The manner of cutting colored stones is much the same as would be used in the case of a diamond, and is usually a modification of the "brilliant" form for small stones, and the "table" for larger ones.

Vitreous enamels, which were certainly used in jewelry from the time of the ancient Etruscans, in the sixth or seventh century B. C., are glass fused upon metal. Enamel glass is colored with metallic oxides, and is opaque or transparent. All ancient enamel work is opaque, oxide of tin being used in all cases, and a coloring oxide as well sometimes. Opaque enamel is easy to manage with a blowpipe, and melts at a low heat. Transparent enamel, which was probably first used in Europe about the fifteenth century, is difficult to manage, and requires considerable heat.

Opaque enamel is suited to cloisonné or champlevé work, but transparent enamel shows best when the metallic ground is carefully engraved in the manner known as basse-taille—the deeper portions showing darker than the more lightly treated parts. I am glad to say that the use of enamels in jewelry shows distinct signs of revival, and there is no more beautiful accessory to gold and jeweled work.

Transparent enamels always do best on fine gold; on silver they are sadly apt to chip off readily, and on copper they are very likely to assume a semi-opacity, but now and then will fire well.

Pearls are formed within the shells of the pearly oyster (*Meleagrina margaritifera*), round some small nucleus. Baroque pearls are of irregular shape, but often contain finely-shaped pearls within them. Much of the value of a pearl depends upon its shape, which cannot be improved without lessening its size. A pearl is made like an onion, in successive layers, so it can be skinned, as it were, and this process is often used to get rid of bad color. The beautiful play of iridescent light on the surface of a pearl is due to the breaking up of the rays of light impinging upon the ragged transparent edges of the fine layers. Very old pearls lose this transparency, and only look like dull lumps of chalk.

Sham pearls have been largely made, and have been, and still are, an important branch of modern industry. The best of these are made at Venice; they are small, spherical beads of glass blown in with powder made of the crushed scales of the blay, a small flat fish, and then filled with wax. A certain proportion of these beads are beautiful, and have very nearly the appearance of the real pearl.

The swastika is probably an ancient symbol of the solar motion, the crampons indicating movement. In ancient mythology the sun was often represented as a wheel. The swastika is found largely distributed. It occurs in leaden and clay idols found at Troy—plentifully in Indian art as well as in Scandinavian. The triskele is found more particularly in Anglo-Saxon art. The Greeks and Romans, however, both used it. The word appears to be originally Sanskrit, "Sa," well, and "as," to be, and is the sign of good wishes, or prosperity.

The sign is frequent on Trojan terra cotta balls and spindle wheels, both forms, swastika and suwastika, being represented. It sometimes occurs in conjunction with the zigzags supposed to represent lightning. It is known also as the gammadion and the fylfot. It represents eventually the highest deity.

Burnouf thinks, the swastika was originally only the two sticks laid at right angles to each other before the sacrificial altars to produce the sacred fire by means of another pointed stick rotated upon them. In this way it may have become a symbol of sacred fire. It is found in early work of all kinds in nearly all the countries of Europe and in many of Asia. A row of swastikas are sculptured round the old pulpit of San Ambrogio at Milan.

It is found sculptured in the catacombs at Rome, in wall paintings at Pompeii, on Celtic urns and ornaments found in Britain, and on terra cottas and gold plates found at Mycenæ, also at Athens and Cyprus. It is also the original motive of the Greek fret.

In the Chaldean astronomy the representation of the sun commences as a circle, soon increased by the insertion of a cross or spokes within it. The Indians also use a simple ring—which to-day remains as the caste mark of the Sauras or sun worshipers.

The triskele is probably the same sign, but with three spokes or rays instead of four. In both cases the rays are frequently found curved, in which case they are often called snake signs. The three legs used as the coat of arms of the Isle of Man, are a familiar form of the triskele. It is doubtless a sign of the Trinity, an almost universal deistic idea among the cultured races of antiquity; as well as the swastika, it plentifully occurs in the art of Northern Europe, having come up from the south.

The ring-cross is a sacred symbol of the stone and bronze ages, and came no doubt from Asia. It may, perhaps, have indicated the wheels of the sun carriage. Divinities were supposed to live in the sun, and so the sun signs in time came to mean the divinities themselves.

BROOCHES.

The articles of ornamental jewelry that we have already considered can all be worn next the skin. They probably were in fact so worn by our savage ancestors long before they found any necessity for clothing, and in a majority of cases they are still worn next the skin. Necklaces and bracelets sometimes are put on over the dress, and rings are rarely worn over gloves. With these unimportant exceptions the manner of wearing the earlier articles of decoration is practically the same as it originally was.

At some remote period primitive man gradually migrated northward from the tropical belt in which he probably first came into existence, and as he felt the colder temperature inconvenient, especially at night, he found it advisable to invent some sort of covering or clothing, by means of which he could obtain warmth. Some races of mankind under these circumstances probably developed hairiness—the survival of them still existing in the hairy Ainus, so well described by Mr. Landor. But no doubt the majority of mankind remained in their comparatively hairless condition until the almost universal use of clothing finally determined their position as hairless. What the first clothing was it is of course impossible now to say, but it may be conjectured to have consisted of belts of grass or leaves knotted together either by their own stalks or by accessory vegetable fibers. When men became hunters, which they did not do until they had progressed far enough to have invented offensive weapons, they no doubt soon used dried skins for clothing. A rough tanning of such skins could have been managed by rubbing them with fat. Then came the difficulty of fastening them. Some savage tribes still wear cloaks which have only a hole cut for the head to go through, and this is likely enough to be a primitive type; then also they might have been tied up with strips of sinew, but at an early stage they were pinned together with a bone or large thorn. Here is the germ of the brooch.

Numbers of such pins have been found in all places where the remains of primitive man exist, and they range from the simplest forms to quite ornamental ones. The heads of the carved specimens show a certain amount of progression, and are often decorated with engraved lines, dots, and circles. Ivory, wood, and bone are all commonly used, and in time, as metal workings became known, these carved pins are imitated in bronze or gold. From the Stone Age, through the Bronze Age, up to the Iron Age, in which I believe we are still considered to be, pins and their derivatives, brooches and buckles, have been universally used, and it is an interesting study to endeavor to trace their utilitarian development as well as their artistic and technical beauties.

Starting with the earliest metal pins, which are of bronze, it soon appears that the head or thickened end is treated ornamentally, hammered flat, and pierced. Into the pierced hole in the top of pins are often found wire rings coiled several times, or single rings, as in plenty of specimens found in Ireland. In other cases of Roman pins found in Britain, there are chains of which a few links only are left, and in one case at least a pin the head of which was threaded with a chain of several links, was found among the *débris* of one of the Swiss lake dwellings.

I take it that these chains at one time were as long as the pin itself, and that the last ring was in all probability hooked over the point when the pin had been inserted in the garment it was intended to fasten. It is understandable that a large pin fastening rough garments of skins together firmly must have a considerable proportion of its point exposed, and this point must have often annoyed its owner by catching in other things than those it was intended for, as well as scratching his own fingers, and generally making itself felt in an unsatisfactory way. It is, therefore, likely that a covering for the sharp point was advisable for many reasons, and I think the chains, remains of which are constantly found, mark the commencement of a series of contrivances for protecting the point itself from injury as well as for preventing extraneous injury.

In all the subsequent developments of the chain-pin, the chain is the part which undergoes change. It solidifies, thickens and becomes ornamental as well as useful, but it appears to develop particularly in three lines, varying in the proportion of the length of the pin to the arc, as well as in the general shape of the arc or its equivalent. Etymology here gives a little helping word to the pin of bone on its way upward to the beautiful brooch—*περόνη* means at first a "small bone," then it means a "pin," then it means a "brooch." The Greeks also fully saw the double-constructive anatomy of a brooch, and gave a separate name to the arc, "*κλεις* ." The French word "broche" means at first a spit, then a brooch. The pin of a brooch goes twice through the material it fastens; the Greeks realized this, and called a brooch " *δ'ιβολος*, " in distinction to the pin of a buckle which, as we shall see, only pierces the material once.

The finest examples of the annular type of brooch are to be found among the Celtic brooches found in Scotland or in Ireland. Several of these have exquisite gold tracery upon them, designed in the well-known interlaced manner characteristic of early Celtic art, the scrolls frequently ending in conventional animals' heads. Jewels of little value, cut *en cabochon* and pieces of colored glass, amber bosses, and now and then fine pieces of vitreous enamel work, occur in the rings of these brooches. The ring part is always very much less in diameter than the length of the pin, and some of the rings are entire, others, as is more common, are pen-annular. In this last case, the pin is run through the material up to the head, then the movable ring is tucked under it, above the material, and given a half-turn, which fixes the whole thing very firmly. The ornamental ends of several of the pen-annular brooches are copied from natural objects, as may be seen in the "arbutus" brooch, having at the ends a conventional arbutus berry. In the more decorative cases, the ends of the ring are flattened out into irregular plaques, and on them the fine jeweler's work and inlay work is done. The most celebrated instances of this are to be found on the Hunterston, Tara, or Ardagh brooches, but there are several others of less celebrity with workmanship of nearly as fine a character.

The pen-annular brooches are not, however, peculiar to Celtic people, as they are really widely distributed, representing as they doubtless do, a very early type. At the present time, they are in great actual use in Algeria, and other parts of Northern Africa, the main difference between these and the Celtic brooches being that, in the case of the African specimens, the decoration is usually carried out as an ornamental extension of the head of the pin itself rather than in the ring. The principle of attachment remains the same.

The second division into which the decorative arc of the brooch falls, is the *circular*. In this case, the diameter of the ring equals the length of the pin. In the first forms of this kind, the ring remains open, but in later forms it solidifies, and is filled up, becoming the prototype of the most numerous class of ornamental brooches. Round, oval, or rectangular brooches belong to this class, and the ornamentation upon them is infinite in character from the almost plain disk to the most elaborate of the beautiful Anglo-Saxon pearled and enameled brooches. All single stone brooches, like the Koh-i-Noor or the Hope blue diamond belong to this class. Among the more celebrated brooches in this division, may be cited the Hamilton brooch, the Lorn, Lochbuy, and Glenlyon brooches.

Fine specimens of the open-ring brooches are found of early Lombardic, Scandinavian, and fourteenth century English work. These have frequently curiously-modeled figures of birds and animals in the round upon them, and the English examples are often set with fine jewels. From the open-ring brooch, good instances of which are not uncommonly found among the Roman remains in Britain, buckles derive directly. The radical difference between a brooch and a buckle is that the pin of the latter only pierces the material it is used to fasten together once, whereas the pin of the brooch pierces it twice. In the case of the buckle, the place of the second piercing may be said to be taken by the fastening of the head of the ring to a strap or the edge of the material. This head is often enlarged into what is called a buckle-plate, which is often beautifully ornamented, especially by early Merovingian and Anglo-Saxon jewelers. Made of bronze or gold, or bronze overlaid with gold, these buckle-plates are often covered with small *cloisons*, into which are set little pieces of flat garnet and a blue or green composition. They are also sometimes, in Anglo-Saxon specimens, adorned with small figures of fish, birds, or animals, treated in a like manner to Lombardic work. The buckle with a bar across it is an afterthought; it first shows on the Glenlyon brooch, but its usefulness soon became apparent, and it is a good example of the curious way in which a certain form may usefully develop from another, and then improve itself on entirely new lines. The existence of buckles, with several pins, is another instance of special development, as also is the new invention of widening the point of the pin itself into a rounded eye, fitted with a padlock. In this case, of course, the holes in the tongue are made very large, the pin having of itself no piercing power whatever.

The third division into which I have divided my brooches, may be called the *linear*, as it gets rid of the ring form, and substitutes a straight line, of metal, or what represents it, for chain or circle. These brooches are more properly known as fibulæ, the straightened out ring is now the same length as the pin, but it is more or less arched, the head of it forming a hinge or spiral, the point turning into a small saucer-like trench into which the point of the pin fits.

The modern safety-pin is quite the same in all essential points as one which was found by Dr. Henry Schliemann at Mycenæ, and the same form, with the arch more or less specialized in design, has been very largely used North and South, East and West. The Greeks made the arch short, and enlarged and ornamented the nose or hollow for the pin to rest in; the Romans made the arch big, and set it with beads of amber and bronze, and fretted it out in innumerable ways, curves, spirals, and all sorts of twists and turns which the fancy of the artist could devise. The Roman fibulæ are more usually made of bronze or silver, but the Greek are largely of gold, and of exquisite workmanship.

Some of the German fibulæ are curiously arranged so as to fasten with the arch downward, and to this arch are fastened fringes and pendants of metal disks and chains. This might be a very useful and decorative kind of brooch in competent hands. I have seen several instances of modern safety-pins the arch of

which is jeweled, but I have never seen one treated in a modern way on the Hallstadt model.

The Romans early enough made their fibulæ of the piece of wire, bent round at the head into a double or triple coil, so as to form a spring. In doing this, they quickly found it was easier to make the small turn on some kind of core, and probably they used a small stick for the purpose; and one day the stick—or perhaps a short piece of metal—stuck in the coil, and the artist saw that it was a decorative feature, and numbers of Roman brooches have this kind of cross-bar at the top. It is, however, often explained as representing the cross, or Tau; indeed, these fibulæ are known as Tau brooches. I think it more likely that the constructive explanation is the safer, as I believe that many of these brooches were made long before the Christian era.

However this may be, the Roman Tau brooches gave rise to a very decorative form of fibulæ. These are the very elaborately-wrought brooches of Scandinavia, which have a large rectangular or semi-circular top. This top is clearly an enlarged form of the cross-bar, but it is so distant from it and so highly ornamented that the connection between the two is not evident at first sight. There are also numbers of beautiful Anglo-Saxon brooches designed on similar lines, but more delicately worked with much more reserve in the lines as well as in the workmanship. The long Scandinavian brooches are usually made of metal alone, where the Anglo-Saxon are largely ornamented with inlays of garnet, and silver lines with niello patterns upon them. In both cases the body of the brooch is long in proportion to the diameter of the rectangular or semi-spherical head, and is equally ornamented.

In early Roman brooches where the turn-over at the head has required some little arrangement so as to bring over the "arc" part in a different direction, the pattern made by the wire curves is peculiar. When the fibulæ reached the northern part of Europe in Scandinavia, the artists there filled in, or covered up, the upper wire with a solid plate, and turned it into what is known as the "boar's head" brooch, but curiously enough the pattern of the original turn of the Roman wire fibula shows in many cases outlined on the top of the boar's head. These large decadent brooches are the ultimate northern outcome of the safety-pin, as they are so heavy and cumbersome that they would pull any ordinary material to pieces. Being the ultimate outcome, they have not developed further at all. In the same way the Celtic annular brooches in their turn are the ultimate western development of a ring fastened at the head of a pin. Both these forms then have, for the present, ceased to develop, but the circular brooch and its endless variations is still alive, and yields a rich field for designer and workman, advantage of which is, I fear, hardly taken to its full extent, although there are signs that a new feeling is growing up with regard to brooch designs. It will, unfortunately, be a long time, I fear, before the taste for small brooch models of favorite toys quite goes out from among us.

PENDANTS.

Pendants as a rule belong to necklaces, but they are so various, and designed in ways which are so peculiar to themselves, particularly in the sixteenth, seventeenth, and eighteenth centuries, that I feel they have some claim to be considered as a class by themselves.

The small pendants which occur numerously in ancient Egyptian, Greek, Etruscan, Phœnician, and Rhodian necklaces, although taken separately, may be considered as true pendants, nevertheless they are sometimes so repeated and strung together, that they become actually integral parts of the necklace itself, and are so considered in their proper place. On the other hand, the pendants now under consideration are made either to be suspended on any chain which may be worn at the moment, or else have a small and unimportant chain of their own—used only for the purpose of suspension. One easy distinction is possibly the surest test of this difference, it is that of size. If, for instance, any pendant exceeds any other pendant on its own chain by a couple of inches or so, I think it is worthy to be considered as a separate jewel.

On necklaces of ancient Egypt appear pendants, among the most curious of which are three large golden flies, on a cleverly-made chain (probably 1800 B. C.), according to Emil Fontenay. The Phœnicians worked pendants charmingly, with delicate granulations. Their jewelry is, as a rule, remarkable for its quality of thinness, and similar granulations show in several of the beautiful Greek and Etruscan pendants, many of which exemplify the art of their time at its best. In some of the Etruscan necklaces are found bullæ, the original form of which is circular and double—two faces soldered together at their edges—but this form soon became modified. The original bulla was really only a form of amulet, as foreign substances were inclosed between its two faces. Rats ears and livers were prophylactics against the evil eye. A dried bat's head induced sleep; other odds and ends cured toothache. Serpent's eggs were likely to cause the success of their wearer in lawsuits. Sometimes they inclosed conjurations against demons and evil influences engraved upon small plates of metal, silver, or gold. The wearing of amulets no doubt originated in the East, and they were not only worn in bullæ, but attached to bracelets, earrings, set in rings, hairpins, and even in belts, or sewn into the garments.

Agates preserved the wearer against bites of insects, and had the power of turning away or dispersing thunder storms, but for this purpose they had to be tied in with lion's hair. The diamond cured melancholy, and quieted trouble or sorrow. Amethyst was a preventive against intoxication, and if the names of the sun and moon were engraved on stones they prevented poison from acting, and frightened away hail and locusts.

Besides the magical contents of the bullæ these sometimes were engraved with powerful signs, as the swastika, already mentioned. The belief in these signs and mysteries dates from very remote times, and is not even now quite extinct. The belief in the efficacy of small pointed pieces of coral or other material against the power of the evil eye is still very strong in Italy, and there are other smaller superstitions without number among uneducated people. The belief of the luck in a horseshoe is still strong, even in our England.

Among the Romans of about the first century, the Augustan age, no doubt cameos were largely used as pendants; coins also, richly set, were also used. Charlemagne, in the eighth century, wore a splendid reliquary as his necklace, which was sent to him by Haroun-al-Raschid. This was buried with him, and was found on his neck when the body was exhumed in 1169. In 1804 this reliquary was given to the Emperor Napoleon I. by the clergy of Aix-la-Chapelle, and latterly it belonged to Napoleon III. Under a pale blue sapphire are set a piece of the true cross and a thorn from the crown of thorns. The sapphire is magnificently set in gold and gems.

Up to the end of the fifteenth century, the majority of pendants were indeed amulets, more or less ornamentally treated, but after that time this character gradually died out, and the decorative value of the pendant alone became the object of consideration. From contemporary portraits some idea can be formed of the almost universal use by great people of pendants of great beauty—crosses, medallions, or only ornaments; but enough of the actual objects of this time exist, to enable us to realize what charming and elaborate works of art many of these pendants were. Vitreous enamels usually play a large part in their ornamentation, and there is a profusion of jewels, and much fine, good work, cast, hammered, molded, and chased in all kinds of ways, and usually a free use of pendant pearls. Where round shapes were used an oval form now is generally substituted, but the more ornate pendants are irregular in form. Cameos are often used, sometimes antique, sometimes Renaissance, set in very beautiful mounts of gold, jewels, and enamels in rich juxtaposition. Benvenuto Cellini is credited with having designed some of these settings—two attributed to him are now at Paris, one of an architectural design.

Some of the prettiest of the Italian sixteenth century pendants represent little ships, a design carried out frequently by jewelers of other nations, but never so charmingly as those of Italy.

During the sixteenth century in France, there were several excellent designers for pendants, and jewelry in general, but as far as is known their designs were not carried out at the time—if ever. The best of these designers were Jean Collaert, Androuet du Cerceau, Jean Vovert, Woeriot, Theodore de Bry, and Stephanus. The designs are largely allegorical, scenes from Biblical history, or love scenes, all inclosed in most elaborate and rich framework. Enamels were evidently intended to be largely used.

The use of ornamental monograms in jewelry began during the fourteenth century.

A charming pendant of Queen Elizabeth in enameled gold is in the British Museum, and shows that the English jewelers, although their output was small, were not behind their Continental rivals in technical excellence and power of design.

Diamonds used in jewelry before the beginning of the seventeenth century (1600) are always cut, either as "tables" or "roses," the "brilliant" not being then invented, and all colored stones were cut in the rounded form known as "cabochon."

The Germans took example by the French enamelers in the matter of pendants, and during the sixteenth century made numbers of such jewels, in the center of which are usually little figures. These are all very decorative and wonderfully elaborate, but they are very commonly overburdened with detail. Some of the simpler ones, on the other hand, are almost cumbrous in design, although richly jeweled and admirably worked from the jeweler's, enameler's, and lapidary's point of view. The Italian works of this kind and period are the best in every way. The decadence of which these over-elaborated works are a sign, eventually culminated in forming a school of its own, which, in its way, is interesting and not altogether without beauty. It is called rococo, and the chief essential is the presence of both enameled work and jewels together.

The Museum at Dresden is rich in specimens of the German work of this kind, and by the munificent bequest of the late Ferdinand Rothschild, the British Museum is now possessed of several specimens of the first importance.

A French jeweler, named Daniel Mignot, during the beginning of the seventeenth century, is supposed to have first set rows of jewels close together in consecutive order. This notion was, of course, very suitable for working the monograms then so prevalent, and it has been more or less used ever since.

From the sixteenth century pearls were much in fashion, and pendants commonly have single pearls or groups of pearls dependent from them.

Toward the end of the seventeenth century pendants are found made of gold only, but exquisitely pierced, chased, and engraved, and some specimens of Portuguese work are remarkable for delicacy of execution; these are sometimes set with very small diamonds.

The well-known Norman crosses of metal work, some of which is excellent, have the settings of the crystals abnormally exaggerated in size.

Sprays of leaves and flowers, and knots of ribbon, during the seventeenth century, are made in metal, and thickly set with crystals—paste or real jewels—particularly by Venetian, French, and Portuguese, followed at a safe distance by English workmen. The best of these are by Gilles Légare, and in the eighteenth century his follower, Pierre Bourdon.

The jewelers of the beginning of the eighteenth century did not hesitate to mix gold and silver in their jewelry. Gold was commonly used for the settings of colored stones, and silver for diamonds.

During the Empire classical taste prevailed, the pendants are beautifully worked; various designs of vases and flowers, enameled and jeweled, souvenirs of the ancient bulla. Cameos once again were the fashion, and diamonds and pearls reappeared after their eclipse during the revolutionary period.

Lockets, so favorite in England during the latter half of the nineteenth century, and not unknown before that time, are pendants, but like the bullæ, they are usually valued for their contents, hair or portrait. Renaissance designs are most suitable for enamels. A few beautiful designs were made by Froment Meurice, but the locket part is usually quite insignificant, the setting being the part which is fully ornamental.

TOOLS.—SUMMARY.

A very interesting point about ancient jewelry lies in the consideration of the manner of its working and of the tools with which it was probably wrought. As a general distinction between the larger methods followed by ancient as compared with modern jewelers, it may be said that the former worked more by himself. His work was rarely parceled out or sub-divided, but was followed out from design to finish by one man. He liked *tours-de-force*, such as a chain of rings made by the hammer out of a single bar, and many instances of the successful working out of such puzzles are known. The use of the hammer, anvil, and file is very ancient, and although no doubt annealing by heat must have been known to early workers in hammer work, the very interesting and valuable discovery of soldering, which very likely was accidentally discovered in following out the annealing process, was not hit upon until a comparatively late period.

In old work is found simplicity of means with variety of results, and there probably was a small *clientèle*; in new work is found complication of means with uniformity of results and a large *clientèle*.

Until the middle of the fourteenth century religious feeling in jewelry largely preponderates, reliquaries of all kinds in rings and pendants. In the fifteenth century, gold and silver variously wrought had chief vogue, buckles and all kinds of ornaments for dress. In the sixteenth and seventeenth centuries flourished the beautiful arts of chasing, enameling, and inlays of various sorts, weight being not so highly considered as just before, but workmanship having a higher appreciation.

The management of small and delicately-designed ornaments now required much soldering and alloys for coloring gold, and the official standards of the precious meals were lowered. Then began a curious struggle between the goldsmiths and the mints, one wanting a low standard and the other a high one. One result of these disputes was to lower the standard for coinage to such a point that it would not pay to melt it up and use it for jewelry. At the present time, for instance, you can purchase for about 1s. 8d. as much silver as is in a half-crown, so that obviously it would not pay to melt up the coin.

Toward the end of the sixteenth century, massive plate came again into favor, and silver was largely made use of for ornamental purposes—Claude Ballin even used it for covering tables. And from this time onward, small jewelry became the vogue—so small, that it frequently is not even hall-marked, and this of course, tends largely to tempt jewelers to use metal of a very low standard.

In France, there has lately arisen a new master who already has hosts of imitators—a sure proof of greatness—I mean M. René Lalique. His work, although original, owes much of its charm to his appreciation of the ancient Greek chryselephantine work—that is to say, the use of materials of little intrinsic value, but much artistic importance, used in conjunction with gold and silver. It is supposed that the great statue of Athenê in the Parthenon at Athens, was made of such work—wood overlaid with gold and ivory, and there are numbers of Byzantine jewels on which it is used. Ivory, pearls, enamels, horn, mother-of-pearl, and many other beautiful materials find a place in the work of M. Lalique and in that of his followers, among whom M. Rene Foy and M. Fouquet are perhaps the most distinguished up to the present.

England, so far, has remained constant to old themes, and then trusted to excellent workmanship and valuable materials. But the French departure is not without its effect already, as in some of our London shops can be seen beautiful and interesting developments which promise well for the future. Excellently designed, and often beautifully worked by hand, many of the new brooches, necklaces, and bracelets are admirable, but there is also the tendency to reduplicate good designs in cast work, which is an unfortunate sign. No condemnation can be too strong for the popular designs of cycles, stirrups, golf clubs, tennis racquets and the rest, which still crowd our jewelers' windows, and which, however richly carried out with pearls and jewels, will always be a blot upon our national taste in art.

Savage tribes have used for their ornaments natural objects easily worked.

The cultured nations of antiquity have generally made their finest pieces of personal ornament of gold.

During the period of the Renaissance gold and silver, colored precious stones, and vitreous enamels were very largely used.

During the nineteenth century the diamond has particularly claimed the attention of jewelers.

IONIZATION OF CAVE AIR.—H. Ebert and P. Ewers have repeated the experiments of Elster and Geitel with respect to the ionizing properties of the ground upon the air contained in it. They wished more particularly to decide whether the ionization of air under the influence of air derived from underground is due to the electrons it contains, or whether it is due to some ionizing power such as those comprised under the somewhat vague title "emanation." To test this, they let the air sucked out of the ground pass through a tube in the axis of which was mounted a solid brass cylinder in such a manner that the air had to pass along a thin cylindrical mantle. The tube arrangement constituted a cylindrical condenser which was charged to a high potential by means of a battery of accumulators, and it was expected that after the air had passed through all its ionization would be lost. But on allowing the air to enter a large glass vessel, the air contained in the latter was ionized by the ground air deprived of all its free electrons. Its conductivity increased about eight times in three hours.

This experiment shows that underground air is not like "activated" air but rather resembles radium and thorium compounds, which while neutral themselves, are capable of ionizing gases by means of the free ions they emit.—Ebert and Ewers, Physikal. Zeitschr., December 1, 1902.

THE PROPERTIES AND APPLICATIONS OF SELENIUM.*

By WILLIAM J. HAMMER.

THE extraordinary property which selenium possesses of varying its electrical resistance on exposure to light is a phenomenon which has been known for a long time; but the commercial applications of this peculiar property possessed by selenium have not been properly appreciated up to the present time.

It is my purpose to invite your attention to a

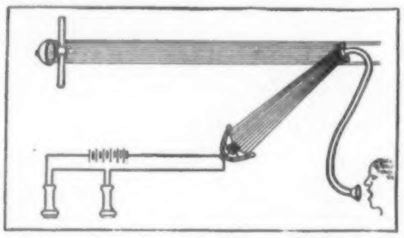


FIG. 1.—PROF. BELL'S RADIOPHONE.

number of the more important applications of selenium which the writer believes will prove of no small interest to the electrical engineering profession, and perhaps stimulate investigations in this most promising field.

The Swedish scientist, Berzelius, discovered selenium in 1817, as a by-product from the distillation of sulphuric acid from iron pyrites. The proximity of the earth and moon suggested to Berzelius the name "Selenium" after the Greek "selene" (moon); this being the result also of the striking similarity of the properties of selenium with those of tellurium, which is a term derived from the Latin "Tellus," (earth). Its atomic weight is 79.5; specific gravity when crystallized, 4.788; its observed vapor specific gravity at 2588 deg. F. 5.68. It is a non-metallic element, which possesses characteristics similar to phosphorus, sulphur and tellurium. When melted at 212 deg. Centigrade and allowed to cool rapidly, it forms a brown amorphous mass of conchoidal fracture. In this condition it is a high class insulator. It has been said that a small piece of it would represent the resistance of a wire stretched from the earth to the sun. When heated for quite a time at a temperature of 100 deg. Centigrade, selenium becomes a conductor of electricity to a limited degree, this increasing with an increase of current and varying according to the direction. Selenium has neither taste nor smell.

The red vapor rising from selenium when subject to intense heat is exceedingly poisonous, and care should be taken when experimenting with selenium in liquid form.

Selenium is usually supplied commercially in a vitreous form. Here are some samples of it, and you will note that it is as structureless as glass and resembles black sealing wax. I also have here some amorphous selenium in which form it is a finely divided brick-red powder. This changes into vitreous selenium when exposed to a temperature of from 80 deg. to 100 deg. C. In order to obtain crystalline selenium, in which form it is useful for selenium cells, it must be kept, as already stated, at from 100 deg. to 200 deg. C. for some time, the black mass being changed into a hard, slate-colored, metallic-looking substance. In this form even the thinnest films are opaque to light, whereas in the vitreous form the film would be transparent and ruby red in color. I have some of these films here for your examination.

Selenium is to-day employed to a considerable extent for the coloration of glass.

In 1851 Hittorf first discovered the effects of temperature on selenium; but it was not until February 12, 1873, that Mr. Willoughby Smith sent a communication to President Latimer Clark, of the Society of Telegraph Engineers of London, calling attention to the effect of light in reducing the resistance of selenium. An assistant of Mr. Willoughby Smith, a Mr. May, who was a telegraph clerk at Valencia, called attention to the fact that some pencils of selenium which had been used to give a high resistance in connection with some of the cable testing work conducted by Mr. Willoughby Smith, showed a marked change in resistance when the sliding cover of the box which held the

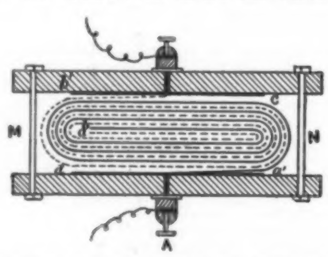


FIG. 3.—MERCADIER'S CELL (BLOCK AND DOTTED LINES REPRESENT THE TWO RIBBONS OF BRASS).

selenium was removed, and the selenium was exposed to sunlight. These selenium pencils varied in length from 5 to 10 centimeters and were 1 to 1½ millimeters in diameter; they were hermetically sealed in glass tubes with connecting wires of platinum at each end. Little credence was given to the original announcement; and it was only after Earl Ross verified this statement, and proved that the action was due solely to light, and showed the effects of the light of different portions of the spectrum, that it met with serious consideration. Since that time much work has been done in investigating the properties of selenium, especially by Messrs. Shelford Bidwell, J. W. Giltay, Lord Ross and Sale, Draper and Moss Hittorf, Adams and Day, Ayrton and Perry, Sir W. C. Siemens, Mercadier, Fritts, Minchin, Ruhmer, Webb, Bell and Taintor, and many others.

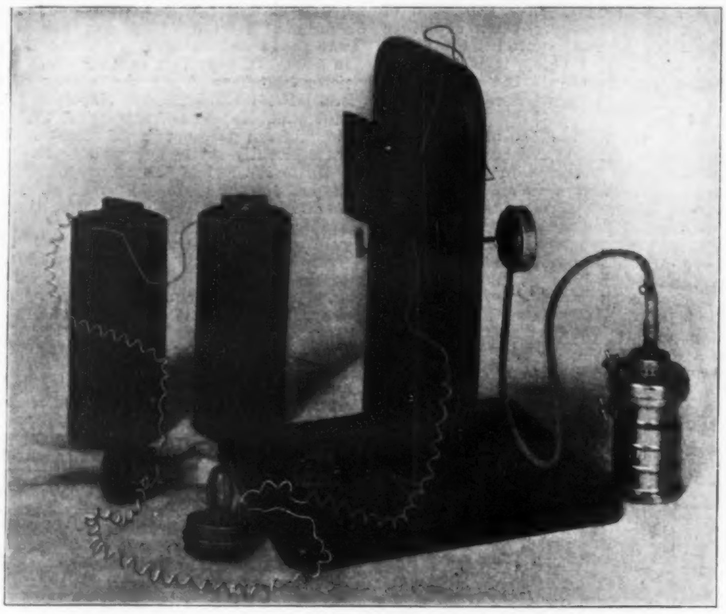


FIG. 4.—MANOMETRIC ACETYLENE FLAME TRANSMITTER WITH SELENIUM CELL.

Alexander Graham Bell some twenty years ago made some interesting experiments with his radiophone, a diagram of which is shown in Fig. 1, in which a mica or glass diaphragm covered with a silvered foil was used to reflect a powerful beam of light upon a selenium cell placed in the focus of a silvered reflector. To the selenium cell were connected a pair of telephones and a battery. At the back of the silvered diaphragm was a flexible tube and mouthpiece into which words were spoken. The sound waves causing the diaphragm to vibrate sent pulsations of the reflected light upon the selenium cell, producing corresponding variations in its resistance and reproducing audible sounds in the telephone. Prof. Bell used this only over very short distances.

In 1898 Prof. H. T. Simon, of the University of Erlangen, discovered that an arc lamp, the circuit of which was in proximity of a telephone circuit, was caused to vibrate very perceptibly and he devised his interesting speaking arc by means of which he superimposed the sound waves produced by the telephone upon the circuit in which the arc was placed. He connected the lamp circuit with the secondary winding of an induction coil, the primary circuit being connected with the carbon transmitter, and a battery. The sounds thus produced originally were very weak; but by employing a suitable carbon microphone, the sound was reproduced to large audiences.

Conversely, the arc could also be used in conjunction with telephone receivers to receive sounds.

It is also found that the transmitter battery may be omitted, and a shunt taken from the arc circuit may be used with the transmitter and a suitable resistance. Again, this resistance may be displaced by storage batteries; and in this case to secure the most satisfactory results, self-induction ("reaction coils") should be placed in the circuit of the arc lamp, allowing the direct current to pass without obstruction; but offering extremely high resistance to the alternating currents produced by the carbon transmitter. By compensating in this way, any disadvantage in the use of the shunt is done away with.

The transmitter may also be placed in shunt with the reaction coil instead of in shunt connection with the arc lamp, and this has the advantage that the rheostat used with the storage batteries may be omitted, provided the windings of the reaction coil are suitable for use as a resistance. By this arrangement, the lack of self-induction in the transmitter circuit permits of a very clear and distinct reproduction, sufficient to be heard by large audiences.

Mr. W. Duddell, of England, has made some most successful talking arcs, which the writer had the privilege of seeing in London over two years ago. In his arrangement in the secondary circuit is placed a condenser, which prevents the lamp current entering the induction coil, but allows the induction current in the transmitter circuit to pass without obstruction; and this arrangement has the effect of greatly increasing the sound. By employing a condenser of from three to five microfarads, he compensates for the difference of phase produced by the self-induction in the circuit, thus producing the highest effect in the arc.

When Duddell uses the arc for transmitting sound waves, he employs in the shunt circuit to the arc a condenser and receiving telephone. It is advisable to employ as long an arc as possible. It has also been found that the Moore vacuum tube and the various types of mercury arc, such as Arons, Hewitt, and Weintraub, are very suitable for this class of work, as well as the carbon arc; and where the latter is employed, either cored or treated carbons are advisable.

The theory advanced to account for the phenomena of the speaking arc, is that variations in temperature of the arc are produced by the variations of the current, and the change in the Joule effect produces a corresponding variation in the volume of the conductive gases in the arc.

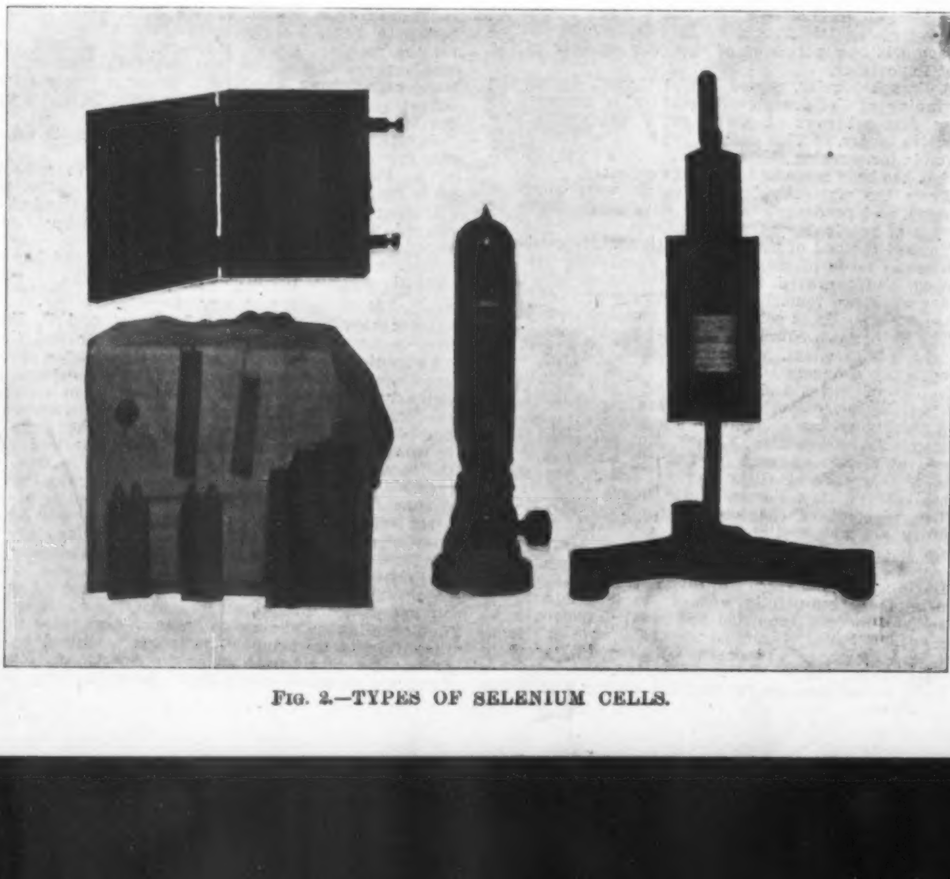


FIG. 2.—TYPES OF SELENIUM CELLS.

* Abstract of a lecture delivered before the joint meeting of the American Institute of Electrical Engineers and the American Electrochemical Society, April 17, 1903.

The most successful and most extensive experiments which have been made with the speaking arc are those of Mr. Ernest Ruhmer, of Berlin, Germany who has employed it in conjunction with his selenium cells for wireless telephony and with remarkable success. Mr. Ruhmer has succeeded in transmitting speech over a

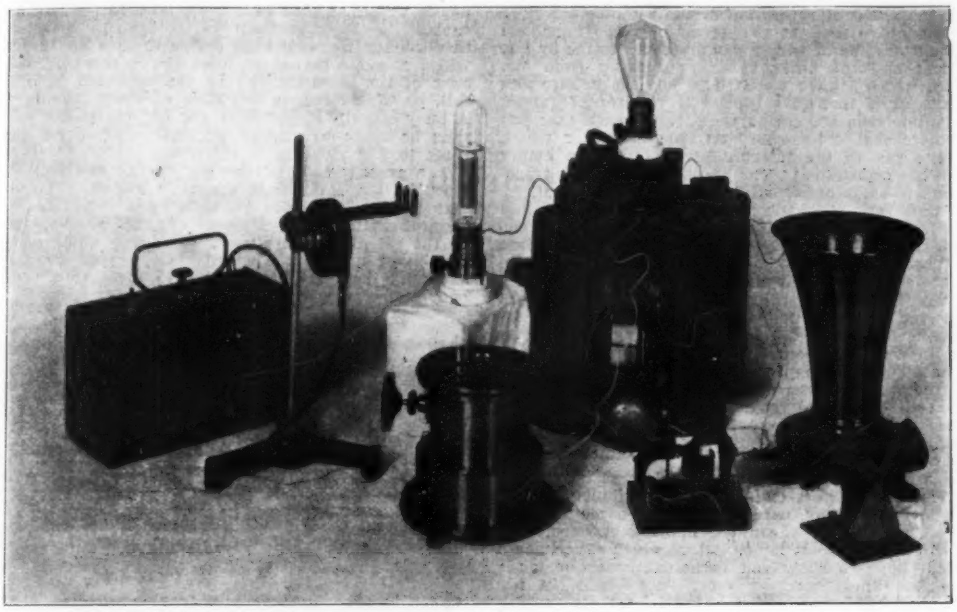


FIG. 5.—ACETYLENE FLAME APPARATUS, RUHMER SELENIUM CELL, RELAYS AND BATTERY FOR OPERATING, ELECTRIC LAMP, BELL, MOTOR AND HORN.

beam of light $4\frac{1}{4}$ miles in length. In his experiments he employed an arc lamp with a flaring arc 6 to 10 millimeters long, using an E. M. F. of 220 volts, the current varied from 4 to 5 amperes at 1 to 2 kilometers, 8 to 10 amperes for 3 to 4 kilometers, and 12 to 16 amperes for 5 to 7 kilometers, and the resistance of his selenium cell was 120,000 ohms in the dark, this falling to 600 ohms in full sunlight. For the transmitting end, Mr. Ruhmer employs a carbon transmitter and a battery superimposing waves on the arc light circuit; and the beam of light is reflected to some distant point, where it is received by a parabolic reflector; in the focus of which is placed a selenium cell connected with a battery and a pair of very sensitive telephone receivers.

Mr. Ruhmer has conducted extensive experiments both by night and by day, and even during fog and rain, on the Wannsee, near Berlin.

Some time ago I suggested to Mr. Ruhmer the employment of Edison's tasimeter, the extraordinary sensitiveness of which is well known. He informed me that he had tried this; but had found it too "lazy:" and stated that he has secured most promising results by the employment of the thermopile; and with this he expects to be able to transmit sound over many miles.

Mr. Ruhmer is about to commence extensive experiments under the direction of the German government in connection with the imperial fleet in the Baltic Sea.

Mr. Ruhmer has also suggested the employment of his photographophone, which I shall describe later, as a means of recording messages received at a distance.

Doubtless many present remember the interesting experiments made by Mr. Hayes at the Electrical Exhibition held in Madison Square Garden in May, 1899, in which music was transmitted over a beam of light. At one end of the garden was placed a telephone, be-

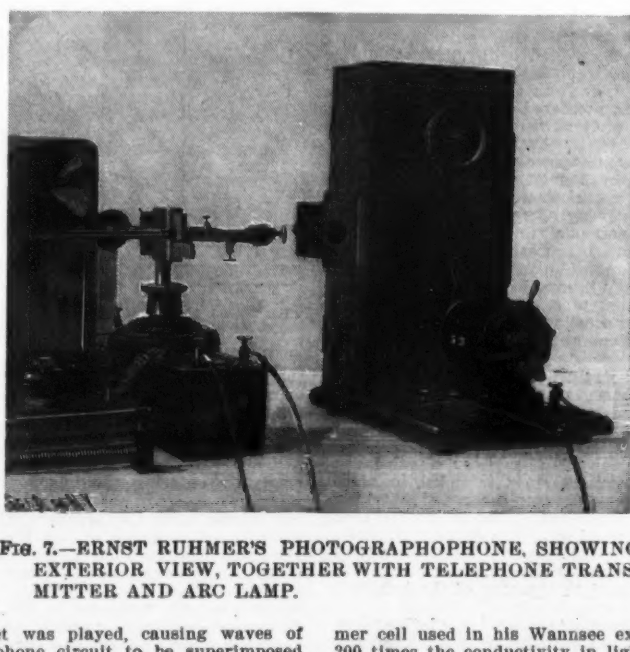


FIG. 7.—ERNST RUHMER'S PHOTOGRAPHOPHONE, SHOWING EXTERIOR VIEW, TOGETHER WITH TELEPHONE TRANSMITTER AND ARC LAMP.

fore which a cornet was played, causing waves of current in the telephone circuit to be superimposed upon those in a neighboring arc light circuit. The light rays from this arc lamp were reflected across the garden, where they were received in a parabolic reflector in the focus of which was a glass bulb containing filaments of carbon. This bulb was connected to a pair of ordinary phonograph listening tubes. The varying light which fell upon the carbon caused variations of temperature inside of the glass bulb which produced the original sounds in the listener's ear. A bulb simply coated with lamp black and containing nothing but air, would answer the purpose just as well.

Selenium cells may vary in resistance from 2,000 ohms to 500,000 ohms or more in the dark; and certain cells may be five to twenty times as good con-

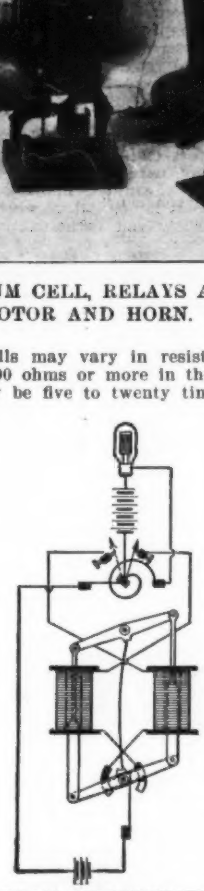


FIG. 6.—DIAGRAM OF CIRCUITS OF SELENIUM BUOY.

ductors of electricity in light as in the dark; and in the case of other cells, notably that of the Fritts' cell, which I have here this evening, and that of the Ruhmer cell used in his Wannsee experiments, will have 200 times the conductivity in light that it has in the darkness; and the ratio may be even higher. They are usually made by winding carefully two separate lengths of wire, either of copper, brass, German silver or platinum, equidistant throughout their entire length upon such substances as slate, glass, mica, or porcelain. The selenium is then spread thinly over the wires, forming an insulation between the two windings. No small amount of skill is necessary to wind these fine wires evenly and equidistant, and to cover successfully these wires with the selenium coating. One way of coating frequently employed is to warm the cell on a metal plate or sand bath heated by a Bunsen burner. When the stick of selenium laid on the plate shows evidence of melting, which takes place at about 120 deg. C., it is drawn slowly over the wires, coating the same thinly and evenly. A steel spatula or a strip of mica can be used with advantage.

Or the strip of material on which the wires have been wound would be laid upon a brass plate covered by a strip of this mica, this being placed upon a tripod with a Bunsen burner underneath. Powdered vitreous selenium may thus be spread evenly over the wires, and the selenium will shortly melt; and where the portions of it crystallize, forming hard lumps, it will be necessary to continue the heating until these disappear. Then the selenium may be spread uniformly with a piece of steel, or better still, a strip of mica, care being taken to cover up the edges. Mr. Bidwell states that the temperature should be carefully regulated, as when it is too low hard crystalline lumps will form, and when too high the surface tension causes the selenium to form in drops, and it is then as difficult to spread as if it were mercury. The proper temperature should be only just above 217 deg. C. and then the selenium is in a plastic semi-fluid condition and can be easily manipulated. When a satisfactory surface is secured, the cell should be placed upon a thick copper plate to cool quickly, when the selenium becomes black and lustrous. The Bunsen flame should then be turned down to give a temperature of about 120 deg., and the cell is then placed upon the hot plate; and shortly, the whole surface of these turns to a dull gray color. The temperature is then cautiously raised until signs of melting begin to appear, generally near one of the edges. When this occurs, the burner is instantly withdrawn and the flame lowered. The dark spot recrystallizes in the course of a few seconds, and the burner is then replaced and left for four or five hours, during which time the selenium should be only a few degrees below the melting point. The coil should then be gradually cooled by lowering the flame gradually for an hour. This process of long heating and slow cooling is generally spoken of as "annealing."

The red vapor rising from selenium when subject to intense heat is exceedingly poisonous, and care should therefore be taken when experimenting with selenium in liquid form.

In Fig. 2 is shown an illustration of a number of types of selenium cells, including the Bidwell, Ruhmer, Giltay, Webb, Clausen & Bronck, Mercadier, and Fritts, which I have brought with me for your consideration.

The two cells to the extreme right and left are modifications of Mr. Shelford Bidwell's cells, the original form of which consisted of two fine copper wires wound side by side on oblong strips of mica with melted selenium spread over the surface, the one to the left being manufactured by Ernest Ruhmer, of Berlin, and by Messrs. Clausen & Bronck, which consists of copper wire wound on slate. The one to the right is manufactured by Mr. J. W. Giltay, of Delft, Holland, and consists of platinum wire wound on slate and covered with selenium. The four tiny cells shown against the white background are made by Mr. Hartwell W. Webb, of New York city, and consist of German silver wire wound on slate. The cell to the right is placed in a sealed flat glass tube. The two lower Webb cells are incased in ebonite. The small round cell is a tiny Mercadier cell made by Mr. Webb. The method of making the Mercadier cell is to use two narrow ribbons of sheet brass or foil, separated by a ribbon of parchment paper rolled up like a spiral spring. This is held between wooden clamps, one surface being ground and polished off smoothly, and a thin layer of selenium being spread over it. An excellent idea of this cell may be had by noting Fig. 3, which shows the standard form.

In the center of the picture is shown a cell of the late Mr. C. E. Fritts, of New York city, for which I

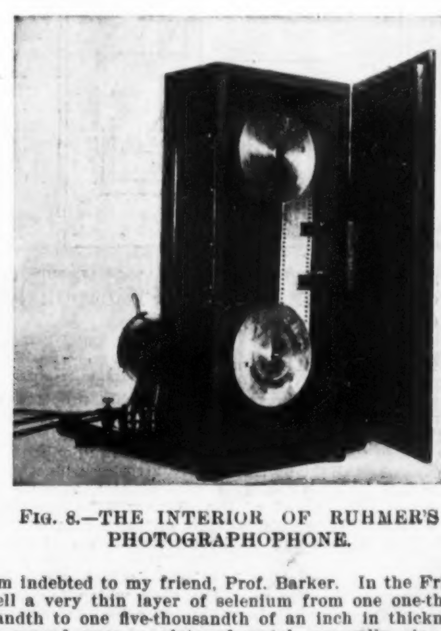


FIG. 8.—THE INTERIOR OF RUHMER'S PHOTOGRAPHOPHONE.

am indebted to my friend, Prof. Barker. In the Fritts cell a very thin layer of selenium from one one-thousandth to one five-thousandth of an inch in thickness is spread upon a plate of metal, generally zinc or brass. The selenium and metal plate form a chemical combination sufficient at least to cause the selenium to adhere and make good electrical connection. The upper surface of the selenium is then covered by

a transparent conductor of electricity, preferably a thin film of gold leaf. Platinum or silver may also be employed. Thus the two surfaces of the selenium are covered by a metal and are connected to the two ends of the circuit. The upper or gold leaf surface, however, permits the light to pass through and affect the resistance of the selenium beneath.

The tall cell in the lamp socket shown is the latest form of Mr. Ruhmer's cell, and this type represents, I believe, the most important development which has been made in the selenium cell, and it has now become most stable, and responds most rapidly to variations in illumination. He employs two copper wires, wound spirally side by side around a cylinder of porcelain, which, after the wires have been covered with selenium, is placed inside of a globe, from which the air is exhausted and it is mounted with a butt similar to an Edison incandescent lamp, and resembles a candelabra lamp. This makes a most convenient method of handling the cell; and by keeping it from the air the disadvantages inherent in all cells heretofore have been very largely done away with.

Another form of Ruhmer cell consists of two fine

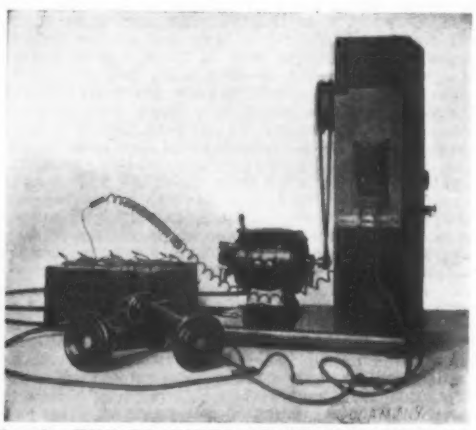


FIG. 9.—THE RECEIVER OF RUHMER'S PHOTOGRAPHOPHONE.

platinum wires wound on a glass cylinder 1¼ inches long and ¾ inch in diameter; the wires, which are 1-32 of an inch apart, are coated with selenium.

Selenium cells are very susceptible to moisture, and it is largely this taking up of moisture which produces the electrolytic effect in the cell, enabling one to connect it with a galvanometer and produce a current by merely focusing the light upon the cell. This phenomenon gave rise to the designation of the photoelectric cell.

Those who have worked with selenium cells know that heretofore they have been most unreliable; varying their resistances from time to time enormously; and in the case where copper wires are employed, there is a selenide of copper formed, which often renders the cells inoperative in a comparatively short time.

To some extent, the cells made originally have been protected by covering them with mica or lacquer or varnish; but placing them in an exhausted receptacle and mounting them in the manner devised by Mr. Ruhmer is, it seems to the writer, a most important step in the commercial development of the selenium cell.

Prof. Bell has made a number of types of selenium cells, his standard form consisting of alternate disks of brass and mica, with the mica disks slightly smaller than the brass, forming a recess for holding the selenium, which is spread over the surface. All the evenly matched disks are connected to one end of the circuit; and all the odd disks to the other end. The cylindrical form of the cell enables it to be acted upon from all directions, when placed length-

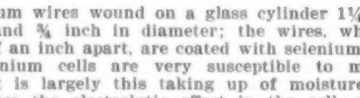


FIG. 10.—THE GENERAL ARRANGEMENT OF CIRCUITS OF RUHMER'S PHOTOGRAPHOPHONE.

wise in the focus of a parabolic reflector. This is also of great advantage in the Ruhmer type of cell.

Selenium cells possess the remarkable property of recovering the original resistances upon the removal of the source of light.

It is well known that in the case of the radiophone, if a beam of sunlight be thus intercepted by a blackened perforated revolving disk, a musical note, varying in pitch with the speed of the disk, will be produced in a rubber tube held at the opposite side of the disk. I have here one of the original forms of radiophones.

A piece of apparatus has been devised consisting of a disk with slits near the edge which is placed near an incandescent lamp, and a selenium cell. If the selenium cell is connected to a telephone and battery, and the disk is rapidly revolved, a musical note will be produced in the telephone, the pitch of which will correspond to the speed of the revolving disk.

Mr. Giltay has recently written me suggesting a very pretty experiment in this line, in which a double vaned Crookes's radiometer is placed between a selenium cell and an arc light shielded by an alum cell. The light from the arc lamp causes the radiometer to revolve intermittently, screening the selenium cell and producing a musical note in the telephone attached thereto, the pitch of which is in accordance with the speed of revolution of the radiometer.

I have here to-night two forms of flame telephone transmitters one of which was presented to me by Mr. Ruhmer and the other I have purchased from Mr. Giltay, which I have mounted as you see it here and as illustrated in Fig. 4 (about 24 volts are required, depending upon the selenium cell). In each case you will note that I have an acetylene generator which conveys gas to the interior of an otherwise empty telephone transmitter. The diaphragm of these transmitters is made of pig-skin, or a similar material. A tiny pipe runs from the back of the transmitter, and ends in one case to a single acetylene jet, and in the other case to three acetylene jets. By talking against the pig-skin diaphragm, the gas inside is made to vibrate and produces a manometric flame. This flame throws its light upon a selenium cell, to which is connected a battery and a pair of very sensitive telephones between 100 and 200 ohms for each cell of battery, in which the sounds spoken into the transmitter are most perfectly reproduced. A thin sheet of paper inserted between the flame and the selenium cell serves to cut off all sound. It is self-evident that these telephone receivers might be at any distant point. I have worked them over considerable distances.

In Fig. 5 are shown a number of most interesting applications of the selenium cell in conjunction with a battery and relay, used for starting a motor, ringing a bell, firing a cannon, blowing a horn, and lighting incandescent lamps, all of which experiments I shall hope to show you in actual operation, as I have had them working most successfully in my laboratory; and you will see that by merely passing my hand before the selenium cell, I can start and stop the motor, turn the light on and off, and ring the bell and blow the horn, or I can fire this cannon, start my phonograph talking, etc. I am indebted to the courtesy of the Marconi Company for the large relay used in certain of these experiments.

I have here also a 3 horse power motor, driving a 1½ kilowatt generator and supplying these lamps which have been courteously supplied by the General Electric Company; and by means of this selenium cell, relay, battery and a motor starter, for which I am indebted to the Cutler-Hammer Company, I hope to be enabled to start and stop the motor by merely passing my hand before the selenium cell.*

In 1886 the writer attended a convention of the Edison Association of Illuminating Companies at Rochester, New York, and during a discussion of contract systems versus meter systems, he gave his experience as chief inspector of central stations of the Edison Company, in dealing with the difficulties met with in supplying light by contract; and he then described a practicable method of utilizing selenium cells to control relays and magnets which would throw off the electric lights on the approach of day and on again at night, thus solving the difficulty of street lighting, and other circuits intended to operate only at night.

On February 12, 1890, in a paper on some experiments with selenium cells, Mr. Shelford Bidwell showed a relay operated by a selenium cell, which threw on an electric lamp and rang a bell, and he suggested the protection of safes and strong rooms by selenium cells, which would be affected by the light from a burglar's lantern, thus giving an alarm. He also spoke of their being used to give notice of the extinction of railway signal lamps and ship lights, and stated the following: "But I do not at present attach any serious importance to such practical applications of these devices. I regard them simply as offering somewhat attractive illustrations of the effect of light upon the resistance of selenium."

This is an important statement from the greatest authority on the subject of selenium, but to-day it will not hold good.

I hold in my hand a small vial containing some "thermit," which was discovered by Dr. Goldschmidt. It consists of oxide of iron, such as one would get off a blacksmith's anvil, or from the rolls of a rolling mill, and is mixed with powdered metallic aluminium. A white-hot iron or molten metal poured into this mixture produces no effect; but if a little barium preparation or magnesium powder be placed on top of this mixture and touched off by a match, an extraordinary reaction takes place, producing a temperature of about 3,000 deg. C., and the energy represented within one second's time in the case of a kilogramme (2.2 pounds) represents an expenditure of 1,260 horse power.

I have seen some very interesting experiments made in welding girder rails, pipes, etc., by this process, and have here some interesting samples of manganese, chromium, ferro-titanium and other metals prepared in this way.

I have also seen enormous holes burned in steel safes by employing thermit; and it would be possible for a burglar to carry some thermit in his pocket and burn a hole in a safe large enough to insert his arm and extract the valuables.

I also saw in Germany last summer a substance called "anti-thermit," which it is intended to place in the lining of safes to prevent the reaction taking place, thus protecting the safe. But a simple plan would be to place a selenium cell in or near the safe, so that the moment the reaction was started, a signal would be given to the police in a similar manner as suggested by Mr. Bidwell in the case of the burglar's bull's-eye lantern.

An important commercial application of the selenium cell has recently been made by Mr. Ernest Ruhmer in connection with his electrically controlled buoy.

Pintsch has constructed a large number of buoys containing compressed gas, which would last from one month to upward of a year; but it was heretofore necessary to burn these lights day and night, it being often impracticable by reason of distance at which they were placed, and frequency of storms, etc., to switch off the gas so that it would not burn during the day time.

Mr. Ruhmer has placed one of his selenium cells in the top of such a buoy connected with a switching device which, as soon as the sun rises in the morning, causes the selenium cell to reduce its resistance, this causing the switching device to turn off the gas, which is again turned on upon the increase of resistance of the selenium cell by the approach of nightfall, or, if desired, in the case of storm coming up. A buoy containing sufficient gas for one month could thus be made to answer without recharge for from three to five months.

The arrangement of the circuits as originally devised by Mr. Ruhmer is shown in Fig. 6. The voltmeter needle has been replaced by a relay, and the apparatus simplified. A single dry cell is interpolated in the selenium cell circuit, as usually employed on the buoy; and this cell will last a year or more, and with the relay, it is placed in the bottom of the buoy and arranged to be absolutely waterproof.

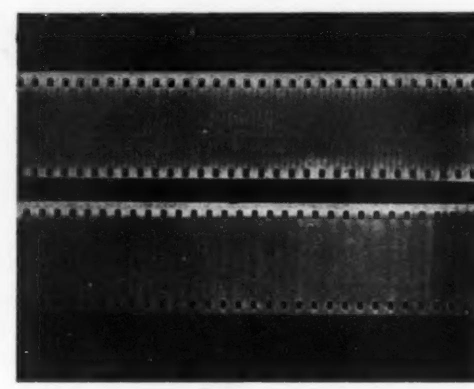


FIG. 11.—PHOTOGRAM USED IN RUHMER'S PHOTOGRAPHOPHONE.

When I was in Berlin last August, one of these buoys had been in operation since the previous October, turning the light on and off every night and morning; and Mr. Ruhmer has recently written me that it is still operating successfully, as are others which he has placed near Hamburg and in the Baltic Sea.

Mr. Ruhmer has also constructed an apparatus employing the selenium cell to which he has given the name "photographophone," which is one of the most remarkable pieces of scientific apparatus that it has ever been my pleasure to see. Figs. 7, 8, and 9 illustrate the general construction of the apparatus, which I shall further illustrate by accompanying lantern slides. In Fig. 10 the apparatus is shown diagrammatically.

It consists of a box containing a gelatine or celluloid film, such as is employed in moving picture machines, and is driven at high speed by means of an electric motor. In the front face of the box is set a cylindrical lens about the size of one's little finger. A short distance away from the box is placed an arc lamp and a telephone. Words spoken or sung into the telephone superimpose the waves in the telephone circuit upon the current flowing in the arc light circuit, and cause a corresponding variation in the light of the arc. The rays from the arc lamp pass through

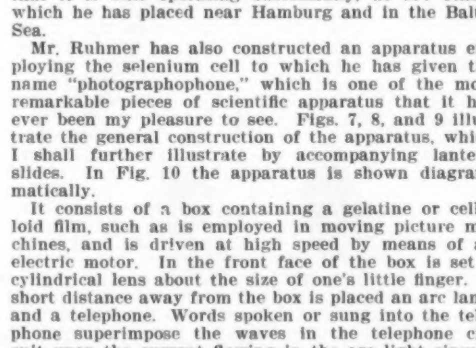


FIG. 12.—CURVE TAKEN WITH RUHMER CELL DURING ECLIPSE, OCT. 31, 1902.

the cylindrical prism already referred to, and are caused to fall in sharp white lines on the moving sensitive film. This film is then taken out of the box and developed; and then shows a series of perpendicular striations parallel to one another, which are really a photographic record of the sound waves originally entering the telephone. Where the striations are fine and close together, the pitch is high, but where they are broader and farther apart the pitch is low. Strips of the film or photograms are shown in Fig. 11. The developed film is next placed back into the box and the motor again started. The arc lamp remains in its original position, but burns steadily as the telephone is not operated. The rays from the arc lamp passing through the lens are therefore quite uniform and the moving gelatine strip acts as a screen to cut off these rays, allowing the light intermittently to fall upon the selenium cell at the back of the box, producing a variation in its resistance and a corresponding effect in the telephone receivers connected thereto. A battery is also interpo-

* The author successfully performed this experiment several times.—Ed.

lated in the circuit with the selenium cells and the telephones. By holding these telephones to the ear, the reproduction of the sound is perfect, as I can vouch for from personal experience with the apparatus.

Mr. Ruhmer contemplates utilizing this photographophone as a receiving instrument with his wireless telephone system, in which he employs a beam of light, as already described.

Mr. Shelford Bidwell has also made a device for producing pictures or writing at a distance by combining the properties of selenium with the chemical telegraph.

Various inventors have endeavored to solve the problem of seeing what goes on at a distance by employing selenium. Among these, Perosino, Senlecq, de Paiva, Cary, Sawyer, Larroque, Nipkow, Gemmill, Liesegang, Heinzerling, Edison, Jan Szczepanik, Dussaud, Otto von Bronk, von St. Schneider, Ayrton and Perry, Korn, and others, have proposed various methods employing images thrown on ground glass or through a photograph negative, or upon mirrors swinging synchronously, or by using revolving perforated screens, for cutting off the beams of light, multiple selenium cells which would be affected by high lights and low lights of the original picture, etc., these devices effecting some method of illumination at the receiving end or producing an electrochemical action such as is produced by the usual chemical telegraph systems, or controlling an electropantograph system such as Gray's telautograph. These various inventions have been termed the telescope, telephote, telectroscope and the telephotograph. But these devices have thus far reached little further than descriptive matter, drawings, and crude experiments.

Various people have suggested the use of selenium cells for photometric purposes; and it is interesting to note that Mr. Latimer Clark suggested this application the evening in which Mr. Willoughby-Smith first brought to public notice the phenomenon of variation in resistance of selenium when exposed to light, to which I have already referred.

Mr. Fritts has suggested making a form of photometer which would be sensitive to lights of different color, as well as of varying candle power, by employing as a film on the surface of his cell a gold foil which transmits green rays, a silver foil the blue rays, and so on; and suggests that a solid transparent conducting film which would transmit all of the rays would be far better and thus remove the color stumbling block in photometric work.

Sir William Crookes has constructed an exceedingly interesting type of radiometer, in which he has coated the revolving vanes on one side with selenium, and on the other with chromic acid. He found that the white light from a sperm candle repelled the selenium, while the yellower light of the wax candle repelled the chrome, thus indicating the relative absorptive powers of the different substances for rays of different refrangibility, resulting in mechanical motion; just as the same selective capacity operates in photography as chemical action.

In 1891 Prof. Barnard, of Lick Observatory, employed a selenium cell as a device for automatically detecting comets, and Minchin has employed the selenium cell quite extensively in his astronomical investigations.

In Fig. 12 is shown a curve which Mr. Ruhmer recently sent me which shows some observations made by means of his selenium cell during an eclipse, these being the only observations which anyone was enabled to make at that time, on account of stormy weather. Mr. Ruhmer has prepared an interesting paper bearing on this and other applications of the selenium cell to meteorology. He made his observations on October 31, 1902.

Selenium is found in Vesuvian lava, and in natural sulphur as a sulphur selenide in the Lipari Islands. It is also found in Norway and other iron pyrites. It occurs in meteoric iron and in such rare metals as eucairite, as a selenide of silver and copper in Sweden and Chili; crooksite, a selenide of copper and thallium with a little silver, from Norway; as clausthalite, a selenide of lead in the Hartz Mountains, from Zinken and Clausthal, in Inverg, Rheinberg, Saxony; Rio Tinto, Spain; Mendoza, South America; as riolite at Culebras, Mexico; as lehrbachite, a selenide of mercury and lead from the Hartz Mountains; as zorgite, a selenide of copper and lead from Glasbach in the Hartz Mountains. Selenium, although widely distributed over the globe, occurs only in small quantities and in some instances is found in native state.

Selenium is classed among the rare metals. Chemically pure crystalline selenium costs about $1.00 per gramme; and the ordinary commercial article about 10 cents per gramme.

LORD KELVIN'S NEW IDEA ABOUT ETHER ATOMS.

By DR. J. G. MCPHERSON, F.R.S.E.

LORD KELVIN, president of the Royal Society of Edinburgh, startled the Fellows, on the evening of the 19th January, with his new idea about ether atoms, in his exposition of the reflection and refraction of light. He has been for years met by serious difficulties in carrying out the practical conclusions of the undulatory theory of light; and these difficulties he exposed in detail.

One investigator after another he found to make ingenious suggestions on the old lines. But Fresnel, Green, Voight and others, with all their ingenuity, could not account for certain discrepancies. But Lord Kelvin, with a master hand, has dispelled all these difficulties by a direct denial of a tenet of the Schoolmen that "two bodies cannot occupy the same space at the same time." Paradoxical as it appears, he assumes the opposite, that two bodies can occupy the same space. That is his main and fundamental tenet, and by it he is able to clear the air of what, for a quarter of a century, has interfered with his coming to satisfactory conclusions on light and electricity.

Lucretius was right in saying, two thousand years ago, that matter was not infinitely divisible, but that atoms and the void constituted matter. These atoms, he considered, were indivisible, originally moving in parallel lines. His fallacy was in assuming that an atom had the inherent *facul* of changing the direction of its motion, so that, by interrupting the parallel lines of motion of the atoms by the alteration of direction at some point, atoms were brought together out of the void to form matter. Yet Lucretius did not dream with his fallacy; for Lord Kelvin, though discarding any idea of the quasi-living power of the atom to change the direction of its motion, assumes that there is an *electrion*, or electric atom within the material atom.

Lord Kelvin assumes that, *prima facie*, according to the laws of dynamics, the material atom is of a spherical form. But this atom is permeated by the ether atom, both occupying the same space. Though the electrion is not material, the ether atom is material, of the fine jelly constituency, infinitely incompressible, though easily changeable in form.

He illustrated the combination of the ether and ordinary material atoms in one spherical form and place by simple experiments. If a piece of common shoemaker's rosin be hung in water, and an iron bullet be placed on the top surface of the hard rosin, the bullet will, through time, slip inside the rosin. If, again, a spherical piece of cork be placed under the rosin, it will work its way up into the rosin, just as the iron bullet wrought its way down.

The spherical atom of matter is not homogeneous, but it is heavier at the center than near the surface. Accordingly, when an ether current comes upon the spherical surface of the material atom it acts differently from the case of coming upon an ether atom. In the latter case, it would pass right through without change of direction. In the former case, the direction of motion would be attracted for a time nearer the center of the atom, on account of the greater density there, and again reach the opposite side of the sphere, finally issuing from the surface of the sphere in the original direction of motion.

The electrion is the marvelous worker in the atom of matter, permeated by the ether atom. It is not always a unit, it may be one, two, or more, but up to nine will account for all the variations of motion, in unstable circumstances; yet there may be hundreds all within the one material atom. Nine he considers the necessary maximum, though one may, in certain circumstances, suffice. This electrion, with the self-occupancy of the ether atom and material atom, is the new means which he has secured for explaining away the difficulties which he has for long experienced in accounting for certain details in polarized light.

This is a bold stroke, and we must wait with patience until his remarkable paper is published, in which he gives startling details to undermine much of what has been done by writers on light. He holds to Newton's law of gravitation, that one body influences another body, though not in contact, but he requires his new idea of the combination or self-occupancy in the same space of the jelly-like ether atom and the spherical material atom.

Even this outline must interest our readers. Without diagrams, and these would be imperfect, I could not give them an accurate idea of the facility of the explanation of the undulatory theory of light in reflection from a perfectly polished silver plane, and in refraction through the diamond, ordinary glass, and water. These Lord Kelvin illustrated by curves, showing the inaccuracy of the curves made by former observers and the accuracy—as tested by experiment—of the results of his hypotheses.—Knowledge.

RADIUM.

THE scientific mind of the world is much exercised by radium. We have been asked many questions concerning it to which it is at present impossible to find answers. The special peculiarity of the new substance is that its properties apparently set at defiance the so-called law of the conservation of energy. We say apparently, and physicists are now doing all that lies in their power to bring about a reconcilement. Much correspondence has already been published from the pens of such men as Crookes and Stoney. For the moment, however, the world will have to content itself with statements of phenomena. What will come next no prudent man will pretend to forecast.

In order to arrive at some comprehension of what is going on in the world of scientific speculation, we have to consider the results of various researches carried out by Sir Oliver Lodge and many other physicists. Up to a comparatively recent period all phenomena that attracted attention and could not be explained offhand were set down to vibrations of that mysterious hypothetical something called the ether. Phenomena quite as inexplicable, and not less interesting, have been passed over, it is not easy to say why. But the Röntgen rays, phosphorescence, and certain performances of electricity did not lend themselves kindly to theorizing manipulation of the ether. The result has been the announcement of the discovery of ions, which, put into the simplest possible form, means that under certain conditions substances send off into space at a tremendous velocity myriads of corpuscles, smaller than the atom to an extent which the mind fails to grasp. The vibratory theory of light has always been unsatisfactory in places. A theory of electricity has never been fully framed in a way to content the scientific world. The ions begin, beyond question, to take the place of ether vibrations in fundamental physics; and it is not impossible that a few years will see the ether deposed in favor of what may be termed a fluid theory, the fluid being composed of ions.

Lest some of our readers should be disposed to say that we are traveling too fast, we quote here a passage from a paper by Prof. J. J. Thomson, of Cambridge University, printed last August in the Popular Science Monthly. This paper concerns itself with bodies smaller than atoms. Speaking of the electron theory, he says: "Thus this point of view approximates very closely to the old one-fluid theory of Franklin. On that theory electricity was regarded as a fluid, and changes in the state of electrification were regarded as due to the transport of fluid from one place to another. If we regard Franklin's electric fluid as a collection of negatively electrified corpuscles, the old one-fluid theory will in many respects express the results of the new. We have seen that we all know a good deal about the 'electric fluid'; we know that it is molecular, or rather corpuscular, in character; we know the mass of each of these corpuscles, and the charge of electricity caused by it. We have seen, too, that the velocity with which the corpuscles move can be determined without difficulty. In fact, the electric fluid is much more amenable to experiment than an ordinary gas, and the details of its structure are more easily determined." There is no reference here to the ether. At present we have to face a question which does not appear to be answered. There is reason to believe that all bodies are emanating corpuscles. What is the difference between these and the corpuscles of the electric fluid?

Radium is a substance discovered by Monsieur and Madame Curie. Its existence was, we believe, hinted at or suggested by certain results obtained in experimenting with thorium, one of the extremely rare elements allied to calcium and used in the Welsbach incandescent mantle. Elaborate research obtained radium from pitchblende, a very scarce mineral. We believe that the details of manufacture have never been made public. It is stated that a very small quantity of radium possessed by M. Curie cost £5,000. It is a dangerous thing to deal with in quantity. Its discoverer tells us that it would probably mean death to go into a room in which there was a single pound of it. A five per cent salt of radium can be purchased in little glass tubes in Paris for about a guinea each tube. For the time being radium is classed as a metal. The substance continuously emits ions with a velocity of about 130,000 miles a second, and these corpuscles penetrate solids and blister and corrode the flesh. Leaving radium for a moment and turning to the now well-known cathode rays, also held to be corpuscular, we know that the energy due to their velocity is enormous. The velocity of the cathode ray is much less than that of the radium corpuscle; yet we find Monsieur A. Dastre writing in the Revue des Deux Mondes: "Jean Perrin has calculated the calorific effect which will be produced by the blows of an appreciable proportion of these projectiles. The quantity of heat which a kilogramme of this matter would generate when suddenly arrested by an obstacle in its course would be sufficient to raise instantly to the boiling point the water of a lake 1,000 hectares in extent and 5 m. deep." Now, radium possesses the property of raising the temperature of substances near it, and this without any apparent loss or gain in itself. So far as we are aware, the radium is not itself sensibly hotter than its surroundings. The rise in temperature of a thermometer through three or four degrees seems to be due to the impact of corpuscles in the way suggested by Monsieur Perrin. On this point, however, the physicists have not yet arrived at definite conclusions which are universally accepted. The fact is that, in popular language, radium gives out heat without any ostensible cause.

It is taken for granted that it is certain that heat energy cannot be created by any substance, and that, as a consequence, radium must get its heat through the medium of some external agency. Sir William Crookes thinks that the energy is supplied by the collisions of the molecules of the air with the metal. It has been pointed out, however, that this seems to be negatived by the circumstance that the quantity of emanations from radium is unaffected by the density of the gas in which it is placed. Furthermore, it is stated that M. Curie has found that radium maintains a temperature above that of its surroundings even when it is prevented by a suitable coating from selecting and arresting the "quick-moving missiles" of the surrounding air. If, however, we accept this proposition as being true, and we take it for granted that radium is heated by the molecular bombardment of a gas, we shall have only changed one puzzle for another. We have, then, to ask how it is that radium should be heated in this way and other substances are not. If the kinetic energy of the molecules of the circumambient gas is converted into heat, then they will by degrees be brought to rest. Sir William Crookes knows what is the amount of kinetic energy in a five-inch bulb exhausted to one-millionth of an atmosphere. Radium in such a bulb cannot give out on this hypothesis more energy than the expanded bulb contains. If, however, the radiation of heat goes on continuously without diminution, then it is clear that the atmospheric impingement theory must be given up. It may be remarked here, however, that there is an analogy between the behavior of radium and that of solid fuel—say, coal. The heat energy developed by combustion is largely due to the conversion of the *vis viva* of the oxygen molecules into heat. The kinetic energy of a pound of carbonic acid gas is much less than that of a pound of oxygen, and we may say that, in a sense, coal gives out heat by the impingement of gas molecules. But the analogy is only apparent. No change of state takes place in the radium; there is no combustion. In another direction, however, there is a very remarkable analogy. A magnet is continually giving out energy without loss. Dare we assume that a magnetic fluid consisting of ions exists? Until the other day heat, light, electricity, and magnetism were all classed as akin. If the kinship still exists, it may perhaps turn out that radium is doing nothing more in one way than a magnet does in another. They both develop, apparently without help, energy. Why and how remains to be explained.—The Engineer.

Liquids for Etching Steel.—

I.

Iodine	2 parts
Potassium iodide	5 parts
Water	40 parts

II.

Nitric acid	60 parts
Water	120 parts
Alcohol	200 parts
Copper nitrate	8 parts

III.

Glacial acetic acid	4 parts
Nitric acid	1 part
Alcohol	1 part

—Drug. Circ.

NEW TRAVELING ELECTRIC HOISTS.

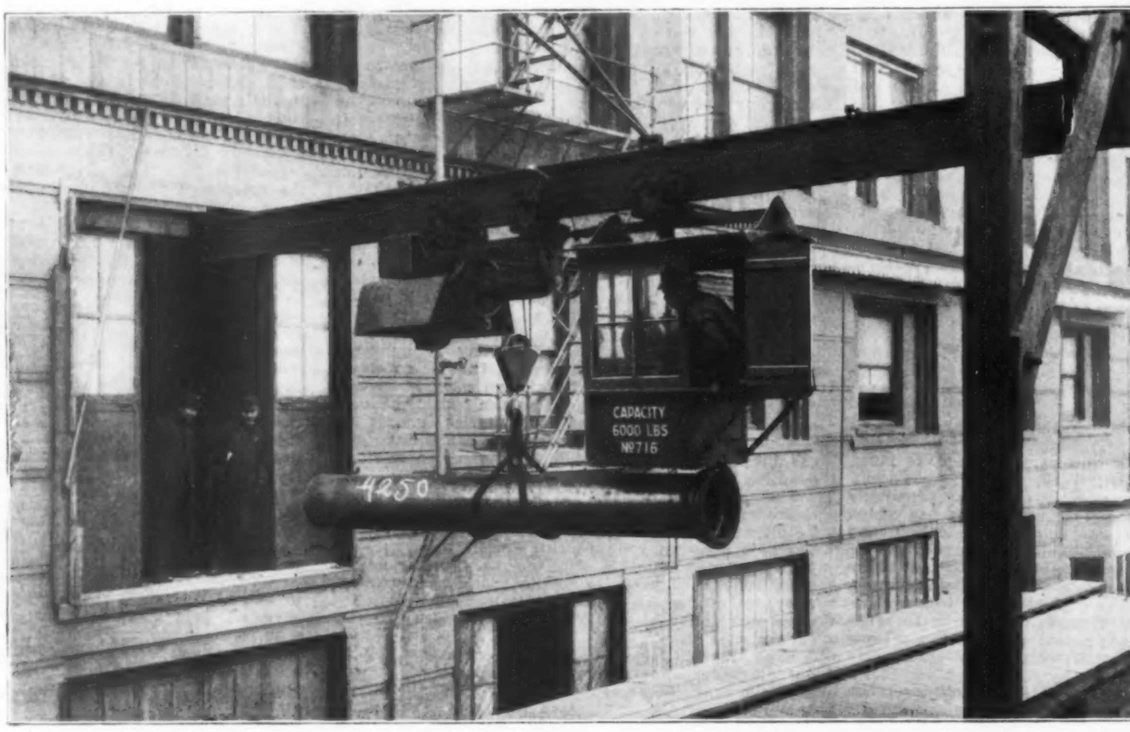
PERHAPS in no manner is the difference so marked between old and new manufacturing processes as in the transportation of material. The changes which have occurred during the last ten years have been more rapid than those in the decade which preceded. And the reason for the change is to be found in the application of electric power to the needs of the industrial plant. Electrically-driven machine tools are now so made that they are no longer considered novelties. Electric traveling-cranes are finding wider and wider use every day.

A modern plant is perhaps more dependent upon a crane than on any other machine. It is the crane's service which has suggested still another type of carrying device to perform similar work but under different conditions. In many manufacturing and storage plants, conveying appliances more than exceed the requirements of any one building, especially where full facilities must exist to carry material to adjoining buildings, to storage yards, and also to transfer loads by a wooden framework, and one within the building is fastened to the lower side of the floor beams. Two trolley wires carried by supports fastened to the top flanges of the I-beam convey the current through collectors to the hoist cage. Direct current of 220 volts is used, though 110 or 500 volts can easily be employed.

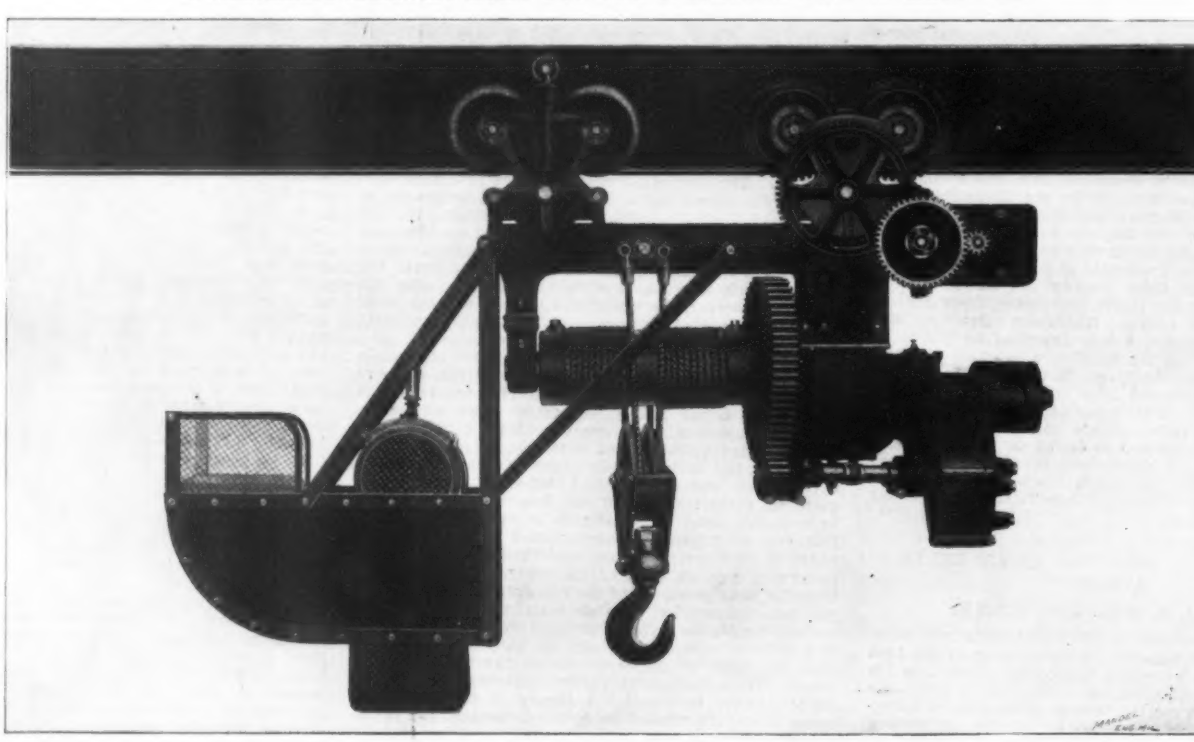
The type of machine illustrated has two motors, by means of which both the hoisting devices and the traveling devices of the entire machine are electrically controlled. These motors are reversed and capable of such variations of speed as the service demands. The operator regulates all movements through the controllers in his cage. He can hoist or travel independently, or he can do both at the same time. The cage is supported from the I-beam by its own swivel trucks. A swivel drawbar attachment to the hoist under the frame is likewise provided. The cage is closed to afford protection from the weather when the hoist is used out doors. A shield is placed over the working parts of the hoist mechanism.

To the main frame of cast steel are attached two of 20 feet. The maximum speed of the hoist under full load is 20 feet per minute, and 50 feet when light. The travel is 150 feet per minute under full load, and 175 running light. The hoist illustrated extends over a railway siding, then through the warehouse into a yard, and over a wagon passageway.

The second of our illustrations pictures a standard type of machine to be made of any one of several sizes with any traveling speed and hoist speed. Perhaps the most marked virtue of the design is to be found in the fact that a clear view of the mechanism is afforded from the operator's seat. This second type may be regarded as the general type. The hoist described in the foregoing for the Clow works was designed to meet special conditions.



A TRAVELING ELECTRIC HOIST FOR THE TRANSPORTATION OF MATERIAL.



A STANDARD TRAVELING ELECTRIC HOIST FOR GENERAL WORK.

from and to cars and wagons. Frequently such work requires a curved track to cover different parts of the plant as well as to pass around obstructions. The lateral span for the carrying device should be small, in order to save valuable room and to prevent interference with other work. The machine itself must possess a variable speed; it should be capable of being stopped quickly at any point; and it should be able to raise and carry loads to any place. For the purpose of meeting these requirements in the warehouse of James Clow & Sons, the machine illustrated was made by Pawling & Harnischfeger, of Milwaukee, Wis., which is remarkable in more than one way.

The runway for this hoist is a single 15-inch I-beam, with the hoist traveling on the lower flanges. When located outside the building, the runway is supported pairs of swivel trucks to sustain the hoist. The traveling motor causes the entire machine to travel, by means of double reduction gearing, meshing into four wheels of the truck. The hoisting-motor is also arranged for double reduction gearing; but at the end of the armature shaft is placed the automatic motor brake. This is in circuit with the hoisting motor and acts to stop the motor quickly whenever the current is off, and to release whenever the current is on. Between the hoist motor pinion and the drum-gear are the load brake and the limit switch. The load brake will sustain the load at any point independently of the hoist motor. In order to lower the load the hoist motor is reversed. The limit switch obviates danger in hoisting the load too high.

The capacity of the hoist is 3 tons with a total lift

CONTEMPORARY ELECTRICAL SCIENCE.*

MAGNETIC EFFECT OF ELECTRIC CONVECTION.—Since the publication of the results of his first experiments on the magnetic effect of a moving charged body, H. Pender has continued his investigations, with results in every way confirmatory of those of the previous experiments, but obtained under new and more favorable conditions. In criticising the previous paper, Crémieu suggests that the agreement between the observed and calculated values of the magnetic field of the moving charged disks was due to the fact that the speeds and potential of the disks were of such critical values that a slight leak in the insulation would produce the observed effect. The author, therefore, varied the speed and potential within as great limits as possible, and to do this Crémieu's own method was adopted—namely, to measure the current induced in a coil when the charge on a rapidly-rotating disk close to it is suddenly reversed. Assuming, then, that

* Compiled by E. E. Fournier d'Albe in the Electrician.

the effect of a moving charge is the same as that of an electric current conveying the same quantity of electricity in the same time, the author calculated the velocity of light from the results, and arrived at values ranging from 2.95 × 10^{10} to 3.00 × 10^{10}. This is a striking confirmation of Maxwell's theory, and a complete refutation of Crémieu's negative contentions.—H. Pender, Phys. Review, November, 1902.

MAGNETOMETERS FREE FROM DISTURBANCE.—It seems hardly likely at present that it will be found possible to devise undisturbed magnetometers corresponding to the galvanometers which have been protected from the disturbance of outside magnetic fields. But H. du Bois indicates a possible method of eliminating disturbances even of magnetometers, if they obey certain rules, although that elimination is necessarily tedious and associated with a certain loss of sensitiveness. As a rule, the effect to be measured is variable from point to point, and may be calculated for special positions. The disturbing effect is much subjected to variation in time, but when the source of disturbance is at some distance, it may, as a rule, be represented by a uniform horizontal component within a certain space. This indicates the possibility of differentiating the two effects. A rough-and-ready arrangement for thus measuring the magnetic moment of a bar magnet is indicated by the author. Two magnetometers are used, and placed at different distances along the same line drawn from the center of the bar. The difference of their readings is then proportional to the magnetic moment, and this difference is independent of any disturbance, such as that of an electric railway. The author describes various differential suspensions, but admits that the choice of a suspension depends altogether upon the particular disturbance to be combated. —H. du Bois, Ann. der Physik, No. 12, 1902.

FORMATION OF OZONE.—The electric discharge produces ozonization in a closed volume of oxygen, but the formation of ozone has a limit which varies with the conditions of the experiment. There exists, therefore, besides the ozonizing effect, a contrary effect which counterbalances it after a time. Now, since for the limited duration of the ozonizing process the spontaneous decomposition of the ozone is negligible, it follows that the electric discharge itself must produce the contrary effect. E. Warburg endeavors to obtain a measure of both effects, and starts from the assumption that the ozonizing effect is proportional to the number of molecules of oxygen present, while the decomposition is proportional to the number of molecules of ozone present. He shows that there is a decided difference between the behavior of a positive discharge and that of a negative discharge in this respect. The maximum percentage of ozone is about three times as high for negative as it is for positive discharges. When, after the negative maximum is reached, the mixture is subjected to the positive effluvium, the percentage falls to the positive maximum. The decomposing activity is the same for positive and negative electricity, but the ozonizing action itself is three times higher for negative electricity. The effect of temperature on both discharges is the same.—E. Warburg, Ann. der Physik, No. 12, 1902.

ELECTRIC ORIGIN OF MOLECULAR ATTRACTION.—W. Sutherland makes a highly interesting attempt to reduce molecular action to the electron theory. He starts with the conception of a neutral gaseous molecule, containing a positive and a negative electron. Such a molecule will have poles like a magnet, and will exert upon a similar molecule an attractive or a repulsive action accordingly as unlike or like poles are nearest. But an attraction tends to increase itself, and a repulsion tends to diminish itself, and so it comes about that on the whole there is more attraction than repulsion. Like magnets, the molecules attract each other with a force varying inversely as the fourth power of the distance. The author shows that a strong contrast is shown to the law of gravitation, and the first condition of the electron theory is satisfied by the fact that molecular mass does not enter into the expression for molecular attraction. It may be considered that the two electrons of a molecule like NaCl, when giving the line spectrum of sodium, revolve round one another in a circle of such size that centrifugal force and electric attraction are in equilibrium. They revolve perhaps entirely within the Na atom. The author calculates a theoretical frequency of revolution amounting to 28 × 10^{14} per second, which is about 10 times as large as that of the visible part of the spectrum.—W. Sutherland, Phil. Mag., December, 1902.

ELECTRIC PROPERTIES OF THIN METAL FILMS.—J. Patterson has carried out some researches on the conductivity of thin metallic films with a view toward elucidating the problem of conduction in metals. The films were deposited *in vacuo* by the cathode discharge. He found that the resistivity of such films was several times greater than that of the metal from which they were deposited. The specific resistance of platinum films which have been subjected to the same treatment remains constant above a thickness of about 7 × 10^{-7} cm. Below this thickness the increase of specific resistance with decrease in the thickness is very rapid. Heat diminishes the resistance of both silver and platinum films, and the thinner the film the greater the decrease. In platinum films the greatest decrease is produced by the electric current. The values obtained for λ, the mean free path of the electron in the metal, are of the same order as those obtained from the change of resistance produced by a transverse magnetic field. In his experiments to determine the thickness of the transition layer, Vincent found $\lambda = 6 \times 10^{-6}$ cm. The value calculated from the change of resistance of pure silver in a transverse magnetic field is $\lambda = 1.3 \times 10^{-6}$ cm., and the author's present value is $\lambda = 1.1 \times 10^{-6}$ cm. These figures are all of the same order.—J. Patterson, Phil. Mag., December, 1902.

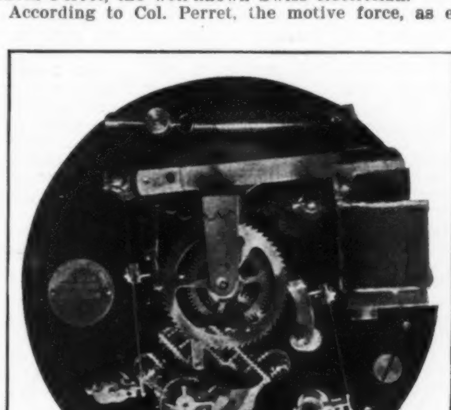
MAGNETO-OPTIC BEHAVIOR OF LIQUID OXYGEN.—According to Kundt and du Bois, the strongly magnetic metals Fe, Co, and Ni show also a strong magnetic rotation of the plane of polarization. Oxygen in the state of gas possesses the smallest Verdet constant measured, and the strongly magnetic solutions of ferric chloride have a negative Verdet constant. This shows that there is no simple connection between magnetic and magneto-optic behavior. F. Harms has, therefore, studied the strongly magnetic liquid oxygen. Its susceptibility is, according to Fleming and Dewar, 228 × 10^{-6}, or four times that of an aqueous solution of $FeCl_3$. He poured the liquid oxygen into a small beaker, on the bottom of which a plane mirror was fastened, and this beaker was placed between two vertical and co-axial electromagnets. Of these the upper one was hollow to transmit a beam of polarized light, which was reflected by the bottom of the beaker upward and analyzed. The double angle of rotation was 2.6 deg., or about one-fifth of the rotation in liquid carbon bisulphide, and about 2,000 times the rotation produced in the gas at the pressure of the atmosphere. The author gives a corrected table of rotations and susceptibilities for a number of solids, gases, and liquids, but fails to discover any regularity.—F. Harms, Physikal. Zeitschr., December 1, 1902.

THE DAVID PERRET ELECTRIC CLOCK.*

By EMILE GUARINI.

A NEW electric clock has been invented by Col. David Perret, the well-known Swiss electrician.

According to Col. Perret, the motive force, as employed in electric clocks, has hitherto been attended with different causes of rapid wear or irregularity in running, among which may be mentioned particularly:



THE PERRET ELECTRIC CLOCK.

1. The more protracted duration of the closing of the circuit than is necessary; whence useless consumption of electric energy.

2. The oxidation of the pivoting parts of the apparatus when the current passes through the pivots.

3. The variation in the relative position of the different parts in contact by the wear caused by the oxidation of the contacts, when these occur with a sliding movement.

4. Closing and opening of the circuit at one and the same point of contact, by which the oxidation caused by the rupture spark increases the chances of imperfect contacts.

The David Perret motor can be applied to every system of spring or of pendulum clocks. It is characterized by a double circuit breaker, designed to avoid all the defects that have been mentioned. The motor and the clock work in the following manner:

A ratchet, *F* (Figs. 1 and 2), receives an advance movement, tooth by tooth, from the spring, *R*, which is energized by an electromagnet, *A*, every time that the ratchet, *F*, has advanced by one tooth, and when the two springs, *D* and *D*¹, are both in contact with the stops, *B* and *B*¹. Fig. 1 shows the position at the moment when the spring, *R*, has been distended by the electromagnet. Fig. 2 shows it at the moment when the spring is on the point of being relaxed.

The extremities of the conductor of the electromagnet, *A*, are connected, one with the contact spring, *D*¹, and the other with the contact spring, *D*. The armature, *C*, of the electromagnet carries a click, *C*², which serves to start the ratchet, *F*. The click, *C*², is pressed against the ratchet, *F*, by a spring, *C*⁴, in order to weaken the force of the spring, *D*¹, sufficiently, and thus diminish the friction on the click.

When the extremity of the armature, *C*, is lowered under the action of the spring, *R*, the click, *C*¹, presses the contact spring, *D*¹, which is inserted in the circuit of the electromagnet, *A*, against the contact piece, *l*¹, of the stop, *B*¹ (Fig. 1), in such a manner that the circuit of the electromagnet is closed, when toward the end of this action of the spring, *R* (Fig. 2), the spring, *D*, comes in contact with the contact piece, *l*, of the stop, *B*. The springs, *D* and *D*¹, are then at the same time in contact; the first with the contact piece, *l*, the second with the contact piece, *l*¹.

The stop, *B*, is connected with one of the poles of one or of two dry or liquid batteries, and the stop, *B*¹, with the other. The stops, *B* and *B*¹, and the two others to which the springs, *D* and *D*¹, are attached, are insulated.

The spring, *D*, is left free to strike against the stop, *B*, or it is removed from it by a second click, *C*³, whose pivot, *e*, is fixed eccentrically on a button, *E*, which can turn in the plate of the movement. The pivot of the click, *C*³, may therefore be placed higher or lower by turning the button, *E*.

The clicks (Fig. 4) do not engage directly with their extremities with the ratchet, *F*; each one is furnished with a lateral pin, whose size is adapted to the function which the click fills.

The pin, *C*¹, of the click, *C*¹, is cylindrical, so that the friction between the pin and the teeth of the ratchet, *F*, may be reduced to the minimum.

The pin, *C*³, of the click, *C*³, is semi-cylindrical, so that it may be easily raised by the teeth of the ratchet, *F*, without exerting too much pressure on the spring, *D*. Too strong a tension of the spring, *D*, must be avoided; otherwise the ratchet, *F*, would experience too great a resistance in its movement.

The contact springs (Fig. 3), *D*, *D*¹, have each several leaves, which, when expanded, are found in different but neighboring planes. The extremities of these leaves are furnished with thin plates of silver or of platinum or other but slightly oxidizable metal, which come in contact with the contact pieces, *l* and *l*¹, also of silver or other slightly oxidizable metal, this contact taking place essentially by pressure.

As these different leaves, when expanded, are not in the same plane, one—*d*² for instance—will leave the contact last, and consequently will alone receive the rupture spark; it alone will be oxidized, and in spite of this oxidation the contact will take place very well with the other leaves, *d* or *d*¹, which will prevent the disturbances so frequently occurring in other arrangements.

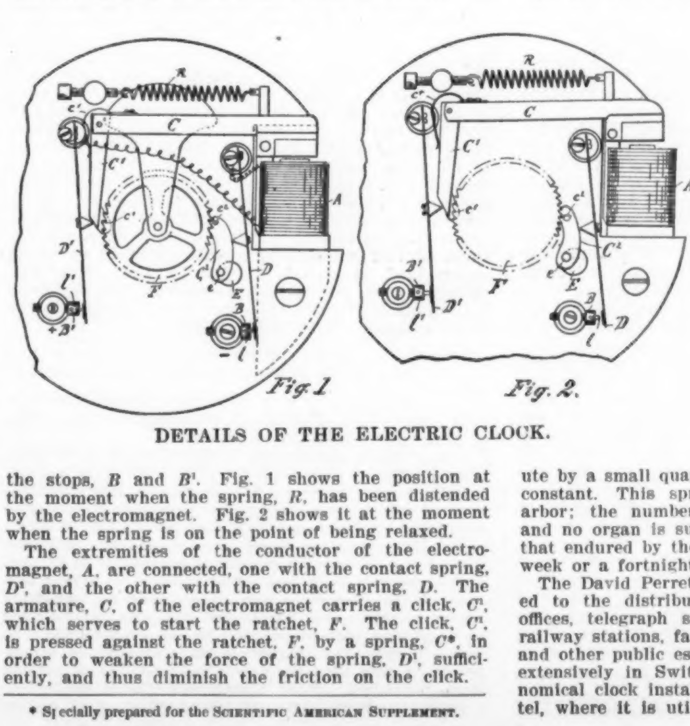
If, instead of oxidation, dust has settled anywhere, the multiplicity of leaves will afford the same remedy as against oxidation.

Such is the arrangement of the David Perret electric motor as applied to clocks.

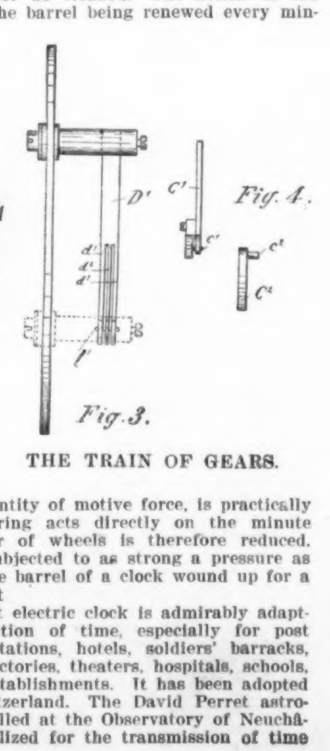
If desired, the spring, *R*, may be replaced with a weight or with a storage battery of any force. The two stops, *B* and *B*¹, may be replaced with one, but carrying two contacts, situated in two different points of the stop.

The simplicity of the mechanism, it must be acknowledged, could scarcely be surpassed. Col. Perret runs his clock with one or two dry batteries, which, once per minute and during about a three hundredth part of a second, have to furnish a feeble current. Their wear is therefore minimized. The durability of the batteries depends on their dimensions. The usual type adopted is guaranteed to last for three years, but the time will usually in most cases be much longer. Some clocks have been going for a long time, and the batteries which maintain them are far from being exhausted.

The electric system (as may be seen from the illustrations) is combined in such a way that the current does not touch any part of the horological movement. It traverses fixed pieces or springs and does not pass through any pivoting piece. There need therefore be no fear of the pivots becoming oxidized. The contacts, studied with the greatest care, in order to avoid their oxidation, are two in number; one establishing the electric current, the other breaking it. Consequently the clock runs with absolute security. The contacts need never be cleaned. The action of the spring replacing the barrel being renewed every min-



DETAILS OF THE ELECTRIC CLOCK.



THE TRAIN OF GEARS.

ute by a small quantity of motive force, is practically constant. This spring acts directly on the minute arbor; the number of wheels is therefore reduced, and no organ is subjected to as strong a pressure as that endured by the barrel of a clock wound up for a week or a fortnight

The David Perret electric clock is admirably adapted to the distribution of time, especially for post offices, telegraph stations, hotels, soldiers' barracks, railway stations, factories, theaters, hospitals, schools, and other public establishments. It has been adopted extensively in Switzerland. The David Perret astronomical clock installed at the Observatory of Neuchâtel, where it is utilized for the transmission of time

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

signals to the different stations, has, at ordinary temperature and pressure, a daily variation not exceeding three or four hundredths of a second, and goes quite as well as the other clocks of the observatory under constant pressure, according to the present Director of the Observatory, Dr. L. Arndt.

[Continued from SUPPLEMENT No. 1429, page 22899.]

ON ELECTRONS.*

By SIR OLIVER LODGE, F. R. S., Vice-President.

PART III.

DETERMINATION OF SPEED AND ELECTROCHEMICAL EQUIVALENT OF CATHODE RAYS.

THE curvature of path produced in cathode rays by a transverse magnetic field, or the amount of rotation produced by a longitudinal magnetic field, constitutes an evident mode of attacking the problem of estimating their velocity.

If the velocity is constant and the magnetic field uniform, the curve into which the beam is bent will be a circle, and its course can be readily traced either directly, after Crookes' manner, by letting it graze a phosphorescent substance, or indirectly by inference from the position of a linear target placed so as to catch the deflected rays.

Consequently there will be no difficulty in determining the radius of curvature; and the theory is the simplest possible, nothing more than stating that the magnetic force, acting on the current element, is the necessary deflecting or centripetal force, required to overcome the mechanical inertia of the particles.

In 1897, J. J. Thomson arranged that the magnet should deflect the rays into an insulated hollow vessel, connected with an electrometer and a known capacity, so that the aggregate charge of the cathode ray particles collected in a given time could be measured by the rise of potential observed. He also arranged that inside the hollow vessel they should fall upon a thermal junction of known heat capacity, connected by very thin wires to a galvanometer (acting therefore as a calorimeter), so as to measure their aggregate energy.

When these brilliant measurements were actually made in the laboratory the atomic nature of cathode rays was, if not actually disproved, at all events rendered highly improbable; for their speed was found to be of the order ten thousand miles per second, or even as high as 1-10 that of light in a favorable case, being always of the order 10^9 c. g. s., while the electrochemical equivalent was of the order 10^{-7} c. g. s., or about 1-1000 that of hydrogen.

Changing the kind or residual gas in the tube, and changing the electrodes, made no difference to this last value. *The cathode rays were evidently independent of the nature of the matter present*: an exceedingly momentous fact. If they were matter at all, they appeared to be matter of some fundamental kind independent of the distinctions of ordinary chemistry. Their velocity, however, depended on the potential difference between the electrodes, in a way that suggested that they were really projectiles urged by the potential gradient acting along a given length of path. They were propelled by the cathode through an aperture in the anode, and the measurement of their speed was made in the tube beyond the anode, where they are traveling by their own momentum. The distance apart of anode and cathode did not, and on the projectile hypothesis ought not to, affect this speed; for though the potential gradient is steeper when anode and cathode are put close together, the length of path during which the particles are subject to it is diminished by a compensating amount, so that the velocity is theoretically independent of the distance between the electrodes, as long as the total difference of potential is maintained; it is the absolute difference of potential that determines the speed. But manifestly if the electrodes are too close together it may be difficult to secure a high difference of potential between anode and cathode, since they may spark into each other outside the tube; and if there is much residual gas in the tube it will likewise be difficult to maintain a high potential difference, because that residual gas, under the influence of the cathode rays, will conduct. Consequently the best speeds are obtained at high vacuum; and if the density of the residual gas inside the tube is constant, the speeds will be constant. The nature of the electrodes makes no difference, unless they give off gas or otherwise make it difficult to maintain the required potential difference.

Although the speed of the particles in cathode rays was thus found excessively great, their energy was only moderate, and their aggregate mass therefore excessively minute; their aggregate electric charge, however, was considerable. They were able to raise an electrical capacity of 1.5 microfarads several volts, sometimes as much as 20 volts, in the course of a second; and in the same way they might be able to raise a calorimeter, whose heat capacity was about 4 milligrammes of water, by 2 deg. C. Nevertheless their mass was so small that it would have taken one hundred years to collect a weighable amount, and then only about one-thirtieth of a milligramme. They traveled with a velocity a hundred thousand times greater than the speed of rifle bullets, and represented the greatest velocity up to that time observed or even now known in matter, if matter they were; and the electrochemical equivalent, instead of coming out in accordance with that observed in liquids, came out some thousand times smaller; that is to say, the charge associated with each particle of the cathode rays seemed a thousand times greater in proportion to the mass than the charge associated with an electrolytic ion, even of hydrogen.

If the flying particles were really atoms, there was no escape from the certainty that they were extraordinarily highly charged atoms; but if, as seemed more likely to the instinct of most of those who worked at the subject, the charge on the flying particles was the same as the charge possessed by an atom in electrolysis, then, assuming that the experiments were correct and correctly interpreted, there would be no escape from the conclusion that the mass associated with the ionic charge in cathode rays must be a thousand times smaller than the mass of a hydrogen atom; in which case the cathode projectiles might conceivably be the detached and hitherto hypothetical individual electrons or atoms of electricity themselves. It would be extremely rash, however, to jump to such a far-reaching conclusion on such comparatively scant evidence. The evidence must be confirmed by other departments of Physics or by other determinations based on a different method; and they must be further scrutinized in the light of the magnetized-radiation phenomenon observed by Prof. Zeeman, of Amsterdam. We will first describe a determination made by another method, and then some striking measurements applied to phenomena which belong apparently to other departments of Physics.

FURTHER MEASUREMENTS OF CATHODE RAY VELOCITY AND RATIO OF MASS TO CHARGE BY AID OF ELECTROSTATIC DEFLECTION.

Another and perhaps simpler method of determining the velocity and ratio of mass to charge was also employed by J. J. Thomson, viz., by deflecting the same rays both electrostatically and magnetically; by introducing a pair of supplementary electrodes, one above and one below the course of the rays inside the vacuum tube, and connecting them to the poles of a low potential battery, a few storage cells for instance, thus obtaining a vertical electrostatic field at right angles to the cathode rays. At the same time a magnetic field, produced by lateral magnet poles or by the lines of force due to an electric current in a circular ring, could be arranged at right angles to both the other directions; and thus the electrostatic deflection could be compared with, or used to neutralize, the magnetic deflection.

Let the cathode rays be received upon a needlepoint covered with phosphorescent material and movable up and down in a measured manner; then the deflection of the rays can be observed by reading how much the needle has to be moved in order to catch a narrow beam which has traveled through a unit length of either an electric field of strength E, or a magnetic field of strength H.

This method appears to give fairly accurate results; and the outcome of the measurements is that when H or CO_2 or air is in the tube—

Velocity $u = 2$ or 3×10^9 centimeters per second,

and $\dfrac{m}{e} =$ from 1.1 to 1.5×10^{-7} c. g. s. units.

The chief difficulty about this mode of experimenting is caused by the fact that the ionization of residual air in the tube causes it to become a temporary conductor, and so to screen the flying particles from most of the electrical influence. There is no guarantee that they feel the full effect of the electric field which is ostensibly being applied; indeed it is not easy to let them feel any of the effect. It used to be thought that they were not susceptible to electrostatic action at all, and this was often adduced as an obvious argument against their being electrically charged particles; but fortunately Thomson soon surmised the cause of this masking of the simple effect to be expected, and succeeded in showing that with high enough vacua and other precautions the screening ionized atmosphere could be removed; and the electrostatic deflection metrically observed.

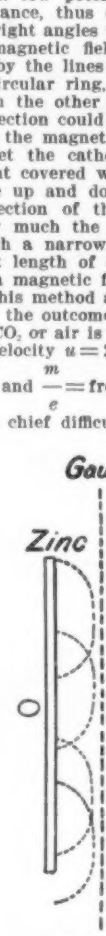


FIG. 1.

FIG. 2.

A B is the insulated zinc plate, C D is the gauze, E F is quartz; the source of ultra violet light is at some distance below, and the vessel can be filled with any gas and exhausted.

DETERMINATION OF ELECTROCHEMICAL EQUIVALENT IN THE CASE OF ELECTRIC LEAKAGE IN ULTRA-VIOLET LIGHT.

The same ratio of $m:e$, or a ratio of quite comparable magnitude, is obtained from phenomena which at first sight appear to be distinct.

One of these phenomena is the effect of ultra-violet light in discharging negative electricity from a clean metal or other surface; a phenomenon the investigation of which was begun by Hertz, and continued especially by Righi and by Elster and Geitel. If ultra-violet light, whether from a spark or from a flame, fall upon a negatively electrified surface, then in general there will be a leak of electricity from that surface, which electricity can be received by any body placed opposite the illuminated one, and can be used to charge an electrometer of known capacity, and so be measured. The writer has made very many experiments in this subject, which, however, have not yet been published. Now Elster and Geitel made the notable discovery that the introduction of a magnet affected the rate of leak, according to the direction of its lines of force. This phenomenon suggested a magnetic deflection of the lines of leak, which were shown by Righi to be singularly definite trajectories, and indicated that the leakage was due to the bodily propulsion of negatively electrified particles analogous to the cathode rays. A vacuum is not necessary to observe the effect, but in a vacuum the effect is more prominent and more accurately measurable. The difference between this case and an ordinary vacuum tube case is that there is no great E.M.F. or gradient of potential applied, there is accordingly nothing of the nature of a disruptive discharge; and in fact there is no leak at all until by the stimulus of the presumably synchronous vibrations of ultra-violet light the molecules are thrown into a state of agitation, and the attachment of the negative charge, or of some negatively charged corpuscles, thereby loosened.

Two things are necessary to get the particles away from the plate; they must be loosened by the impact of ultra-violet light—the direction of polarization of this light having a very decided influence—and the surface to which they cling must likewise be negatively charged, so as to repel them. Neither light alone nor electrification alone will produce the effect; co-operation is necessary.

J. J. Thomson devised a most ingenious method of carrying out this experiment in a metrical manner, and of deducing from it the electrochemical equivalent of the charged particles, that is to say the amount of matter which each contained compared with the electric charge which each carried. To this end he employed the usual arrangement of a small negatively charged zinc plate on which ultra-violet light from a distant arc-lamp could shine, through quartz, and also through a parallel piece of wire gauze connected with an electrometer. The distance between the zinc plate and the metallic gauze was variable, and the experiment consisted in observing how much electricity reached the gauze from the negatively charged plate, under the influence of light, first without, and then with, a magnetic field of measured strength applied crossways to the region between them.

A little calculation of extreme beauty showed him that the paths of the flying particles under magnetic influence would be cycloids, whose generating circles contained the ratio m/e as well as the ratio of electric to the magnetic field, E/H^2; that is to say their trajectory, if it could be observed, would involve the electrochemical equivalent required and likewise the ratio of the electric to the magnetic field applied, as well as the absolute strength of the magnetic field.

The apparatus employed in determining this critical distance is shown in Fig. 2. The sharpness of actual experimental observation of the critical distance was not found quite so great as this simple theory would indicate, because of disturbing causes, one of which was the presence of some residual air, interfering with the perfectly free path of the moving bodies; nevertheless it was sharp enough for fair determination, and the result was again, in this case also, that the ratio e/m came out 10^7 c. g. s., or more exactly 7×10^6; corresponding closely with the values found by J. J. Thomson, confirmed subsequently both by Lenard and Kaufmann, for the cathode ray particles.

Another phenomenon on which measurements were made was the discharge of electricity from an incandescent carbon filament in an atmosphere of hydrogen. This also is subject to disturbance by a magnetic field, as was shown by Elster and Geitel; and a series of measurements, on lines similar to the preceding, resulted in a value—

$$\frac{e}{m} = 8.7 \times 10^6 \text{ c. g. s.,}$$

a value of the same order of magnitude as before, one thousand times greater than the electrochemical or electrolytic value for hydrogen, and many thousand times greater than for other substances, but always constant and independent of the nature of the substance present.

The only things which give the ordinary electrolytic value for this ratio are the *positive* carriers. These are not so easy to observe, but Wien has examined these by detecting and measuring the slight magnetic deflection exhibited by certain rays behind the cathode in a vacuum tube, which Goldstein discovered and called *Kanal-strahlen*, and which Ewers proved were carriers of positive electricity. Wien has shown that they move slowly, and that in hydrogen their ratio e/m is of the order 10^4, that is to say the proper value for a hydrogen atom or ion; and with other substances the ratio has been found to vary with the substance and approximately to equal the electrolytic value, for these positively charged particles. J. J. Thomson has likewise made measurements on the positive carriers by means of the discharge from incandescent filaments and other positively charged hot bodies, and has confirmed Wien's results.

Thus it is forcibly suggested that whereas the positive carriers of electricity are *ions*, consisting of a unit + charge associated with an atom, the negative carriers appear to be dissociated from the main bulk of the atom, as if they were only fractions or fragments or constituents or appendages of an atom, which, detached and flying loose, are able to attain to prodigious speed; since any acceleration to which they are subjected is a thousand-fold greater than it is even for an atom of hydrogen, weighed down and burdened as that is with a mass of inert material and subject only to the very same propulsive force.

Think of the mobility of a set of particles which experienced the usual gravitation intensity g and only 1-1000 of the mass to carry. There is no known way of thus intensifying gravity—there are plenty of ways of diluting it, e.g. Atwood's machine, an inclined plane, etc., etc. But such a mobile particle as that we are now considering would drop under the influence of gravity not 16 feet in the first second, as everything we know does near the surface of the earth, but 16,000 feet, or about three miles; and would in one second acquire under gravity a velocity of six miles per second, enough almost to carry it out of the range of the earth's attraction altogether, and more than enough to carry it round the world.

* Excerpt from a paper read before the Institution of Electrical Engineers and published in the Journal of Proceedings of the Institution.

The acceleration to which such particles are subject in a vacuum tube is far greater even than this, because there the forces are so prodigious; gravitation force on ions is almost infinitesimal compared with common electrical force on their charges. Suppose, for instance, that they are in a field such as easily occurs in a vacuum tube, of 3,000 volts per centimeter, one-tenth of what ordinary air will stand, or ten electrostatic units. The force urging one of these carriers to move is then $10 \times 10^{-10} = 10^{-9}$ dyne; the mass being moved, if it is a whole atom of hydrogen, e. g., if it were a positive carrier in a hydrogen atmosphere, is only 10^{-24} gramme, and accordingly the acceleration it experiences is 10^{15} centimeters per second, or a billion times g. Whereas if it were a negative carrier, in any atmosphere, its acceleration would be a thousand times greater still.

The velocity acquired in passing over a distance of five centimeters under this force is 10^{8} centimeters per second for a positive carrier, and 3×10^{9} centimeters per second for a negative carrier; and these are approximately the orders of magnitude actually observed.

Thus the hypothesis becomes more and more justified that these units of electric charge can separately exist; perhaps carrying with them part of the atom, in which case they might be called corpuscles, having a material nucleus; perhaps pure disembodied electricity, whatever that may be—an electrical charge detached from matter—in which case they would correspond with those hypothetical entities familiar in theoretical and mathematical treatment as "electrons."

(To be continued.)

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

American vs. European Manufactures in Cuba.—The Department has received from the United States legation at Havana, under date of April 22, 1903, the following data showing trade opportunities in the Cuban market in the lines of machinery, boots and shoes, and manufactured cottons:

Machinery, Fittings, Structural Steel, Etc.—The American products in this line suit the Cuban trade and are superior in quality to those which come from Europe. The existing American prices, with the exception of those for machinery, are now about 50 per cent in advance of European prices. The quality and efficiency of American machinery, however, overcome any difference in price between it and European machinery. Although the haul is much longer from Europe than from New York, the freight rates to Havana are generally lower from Europe than from New York. As a rule, the freight rates from New Orleans and Mobile are the same as from New York, depriving Cuba of the advantage of its close proximity to the manufacturing centers of the Southern States. Under normal conditions, deliveries can be made quicker from the United States than from Europe, but during the past year it has been almost impossible to get goods with any promptness from the United States, and this has occasioned a loss to our trade. Breakage on American goods, due to careless packing, is another drawback. Generally speaking, the European goods can be bought on six months' time, while it is unusual for the American merchant to sell for anything except cash against shipping documents. American merchants might find it of advantage to allow sixty days; but the extension of credits, owing to the difficulties of collection, should be a matter of careful inquiry. It has been suggested that our manufacturers should select reputable and sound firms in the larger Cuban cities as their representatives, quote them their lowest prices, give them sixty days' time, with 2 per cent cash discount, and send an expert twice a year to Cuba to instruct and co-operate in handling the business.

Boots and Shoes.—Cuba offers an excellent field for the American shoe manufacturer. At present Spain almost wholly controls this market. It will be necessary for our manufacturers to take into consideration the following facts in connection with this market if they wish to secure it. The Cuban foot is small, with high instep, hollow on the shank and slightly curved, owing probably to the use of the old French last. Shoes for the Cuban trade must have an extra-high instep—i. e., a D shoe should be E on the instep, though Spaniards and colored people usually wear the regular measures. Women's sizes run from 1 to 9 in half sizes, and sizes above 6 are few and mainly for the colored trade. The widths are D and E, with a small percentage of C. The demand is for light-weight and light-colored shoes, tans, and russets, preferably straw color. Women prefer narrow-toe last and tip. The latter should be straight or pointed; heels light, curved, and not very wide. Wood-covered heels sell well, because of lightness. Shoes should have oak inner sole, and care should be taken to prevent stainage of hosiery, which is often white or of light color. Soles should not be extended, but trimmed close to the upper. Misses, children, and often youths wear the same style of shoes, viz., high cut, lace or button, McKay preferred, square edge, light weight or medium sole, narrow or medium toe, all with straight or pointed tip, high instep, spring heel, D and E widths, sizes running from 2 to 7 and 11½ to 7. Men and boys wear mainly bals, with some buttons. Oxfords are not much in demand. Sizes run from 1 to 4½ for boys and 5 to 10 for men, sizes 6 to 8 prevailing; all half sizes. Lasts should be made hollow on the shank and flat on the sole, taking a little higher heel than the average American shoe. Widths D and E; very few C. Medium and narrow toes, straight tips, medium and light soles, square edges favored. It is preferred here that bals and Oxfords should close on being laced. Stiff counters should be avoided. Every care should be taken to make a cool shoe, and for this reason as little glue as possible should be used. Finish counts for more than the wear in this market. Cheap and medium grades are good sellers.

Packing, Invoicing, Etc.—All shoes should be packed in single cartons, on one end of which is pasted a small label giving the stock number, size, and width of their contents. Each assorted dozen single-pair cartons of women's, misses', and children's shoes should be packed together, or wrapped in manila paper with proper label at the end of the carton. Men's and boys' shoes should be packed in individual cartons. Cartons should be as small as possible, on account of freight charges; but cases should be large, for the same reason, and should contain at least 10 dozen men's, 15 dozen boys', 30 or 40 dozen women's, and from 40 to 100 dozen misses' and children's shoes, and should also be made to measure so as not to waste space. Freight charges are 10 cents per cubic foot from New York. Cases should be wire strapped and the customer's instructions with regard to marking and numbering carefully followed. Triplicate invoices and bills of expenses are necessary, all made out in indelible ink. Carbon copies are not allowed. Invoices should show mark and number of cases, gross weight and contents, and the number of pairs, with detailed sizes and prices. All discounts should be deducted from the total of invoices. Each invoice must be certified in the handwriting of a properly authorized person, preferably a member of the firm. In the margin opposite each item should be stated the proper stock number, to facilitate separation or unpacking. Bills of expenses should read, "This covers all expenses," and must be signed, like the invoices, by a member of the firm. Bills of expenses and bills of lading should be sent by the steamer carrying the goods. Invoices may be sent ahead or with the goods. They must be exact and carefully prepared; any discrepancy between the invoice and shipment makes the goods liable to seizure. The present duties are: Men's shoes, 5 to 15 cents per pair; women's and misses', 10 cents and upward; children's, 5 cents to 9½ cents. In addition all pay 10 per cent ad valorem. Manufacturers, it is said, should sell through but one jobber to this trade. Care should be taken to fill orders as promptly as possible and small orders should not be neglected. The total shoe trade amounts to about $2,000,000.

Print Cloths.—A finished print cloth, known in the United States as a 7½ to 8 yards to the pound when finished, is being imported into this market and invoiced at a price per yard which amounts to 64 cents a kilogramme (2.2 pounds). This cloth is woven and printed in or near Manchester, England, and is the cheapest and most sightly cloth of its kind that comes to this market; consequently, it furnishes the strongest competition to be overcome. The invoice price of this cloth is 1 13-16d. (3⅝ cents) per yard. This cloth is woven two in a width and printed and split after being finished, measuring, when ready for shipment, 24 to 25 inches. It varies in weight and is sometimes invoiced at 1 9-16d. (3⅛ cents) per yard; but at this lower price it is reduced in weight, making the price per kilogramme (2.2 pounds) the same as the cloth invoiced at 1 13-16d. A cloth similar to the English, made in Spain and sold in competition, is invoiced at from 1 to 1.15 reales (3¾ to 4 cents) per meter (1.09 yards). This cloth is woven and made ready for shipment very much like the print cloth made in the United States, being woven 26 to 27 inches wide with the selvages. The average kilogramme (2.2 pounds) price for this cloth is about 70 cents—about 10 per cent higher than the English cloth on the kilogramme price.

The American finished print cloth in competition with that of Great Britain and Spain is a cloth measuring 24 to 25 inches when finished and is invoiced at 3¾ to 4 cents per yard, the kilogramme price not varying more than 5 per cent from that of the British cloth—64 cents per kilogramme. The colorings and finish of the American cloth are generally better than either the Spanish or the English. It will be seen by comparison of the cloths made and shipped from these three markets that the American manufacturer at present is furnising the same amount of material, and at the same price, as the British manufacturer, and at from 9 to 10 per cent cheaper than the goods manufactured in Spain.

Piece-Dyed and Printed Drills.—A piece-dyed cloth 27 to 28 inches wide, made in Manchester, an imitation of khaki and a very important item in drills for this market, is being invoiced in Manchester at from 5½d. to 6½d. (11 to 13 cents) per yard. A cloth made in the United States of equally fine construction and coloring is being invoiced at 11½ cents. These cloths pay under paragraph 116, Letter D, of the present tariff. The average price, approximately, of printed drills in the United States and Great Britain is from 50 to 55 cents per kilogramme (2.2 pounds). These pay, under paragraph 116, Letter C, at 32 cents per kilogramme, plus a surtax of 30 per cent.

Cotton ducks made in Barcelona are invoiced for this market at from 52 to 55 cents in United States currency per kilogramme. The same ducks billed from the United States average 52 cents per kilogramme. These pay, under paragraph 114, Letters B and C, at 17 and 23 cents, respectively, per kilogramme, without surtax, the average price being 20 cents.

Knitted Stuffs, Hosiery, Underwear, Etc.—The comparison with Spain is made because the bulk of this merchandise is at present imported from that country. An invoice of hosiery made in the United States, in sizes from 6½ to 9 and at prices from 65 to 90 cents per dozen and from $1.10 to $1.50 per kilogramme (2.2 pounds), does not vary in prices per dozen and in prices per kilogramme from similar goods from Spain more than 5 per cent. These goods are classified under paragraph 122 of the tariff and pay from 70 to 90 cents per kilogramme—an average of 80 cents per kilogramme.

Cotton Goods for South Africa.—The Austrian Commercial Museum announces that cotton prints find an extensive market in South Africa, being used especially by the Boer population for women's and children's wear. The following details are from the publication of the museum:

"A strong article, indigo-dyed with small patterns and colors which do not fade in washing, is in greatest demand. The English manufacturers have not succeeded in furnishing a product at the same price as their German and Dutch competitors. Another article in good demand in South Africa, which is in part supplied by Holland and Germany, is 'flannelette.' This is made of various kinds, either of one color or with stripes of colored yarn, or printed in different patterns.

"For goods dyed in the piece very light colors must be chosen; if colored yarn is used, it is advisable to have a combination of stripes and checks. Tasteful and original patterns are in favor, but the goods should be heavy and durable. The reason that the German article is more in favor than the English one is on account of its greater width. The price also is of importance, a quality retailing for from 6d. to 8d. (12 to 16 cents) per yard meeting with the largest sales. The largest and most important imports of the South African textile trade are cotton blankets. Seven years ago they came exclusively from England, while to-day Belgium furnishes the largest part.

"The blankets are white or colored, smooth, and with a colored border, or white, with colored stripes. They are made of unbleached cotton. The sizes differ according to the market and the wishes of the dealers. It is specially important to send blankets of light and gay colors. They are mostly bought by the Kaffirs, who are to be found in the suburbs of all large and small towns in South Africa.

"The female Kaffirs use mostly cotton goods, either of bleached or unbleached yarns, dyed with lively colors or prints of fancy patterns, in various widths. They use them for loin cloths, belts, shawls, turbans, or dresses. Each tribe calls for certain kinds of these goods. The English have studied the market carefully and know the tastes of the various tribes.

"The dress of the male Kaffirs is much more simple; it consists of a loin cloth, several ornaments, and the above-mentioned cotton blanket, which the native prefers in white, as he usually paints it himself.

"Cheap ready-made clothing finds a sale. The native who comes into the city or settles in the suburbs is forced by law to wear European dress. Oftentimes the native remains in the cities for a short time only, returning after a few weeks to his 'kraal.' In this case he buys the cheapest kind of clothing; if, however, he intends to remain longer and receives fair wages he buys a better quality. Woven goods and underwear, on account of the climate—which is very changeable—are articles of necessity.

"German woven goods, on account of cheapness, find a ready sale. Socks should be seamless and well dyed. Of the more expensive woolen goods, the English are the favorites. In the cheaper kinds, however, it would seem that England cannot compete. These are mainly cotton goods, mixed with sheep wool (Angola), well dyed, and of good appearance and finish. Light and lively colors are in demand."—Richard Guenther, Consul-General at Frankfort.

Swedish Wood-Pulp Market.—Consul R. S. S. Bergh writes from Gothenburg, April 22, 1903:

Swedish newspapers state that by reason of the unsatisfactory condition of the wood-pulp market, Swedish and Norwegian manufacturers have agreed to diminish their production. According to reports, 39,834 tons of paper were exported from Gothenburg during the year 1902, or nearly 64 per cent of the total export from Sweden, and 7,497 tons of pasteboard or building paper (nearly 92 per cent of the whole). The quantities of wood pulp exported from Gothenburg were: Chemical, dry, 40,064 tons, or nearly 25 per cent; chemical, moist, 4,753 tons, or more than 47 per cent; mechanical, dry, 22,339 tons, or more than 69 per cent; and moist, 7,604 tons, or more than 14 per cent of the total export from Sweden.

Trade Notes from Andalusia.—Jeres is the richest city in Andalusia. The long experience in cultivation of grapes and the skillful mixing of wines has made this place eminent in its special trade. It is the great entrepôt of sherry, with storehouses which contain wine 100 years old, some of it valued at $10 per quart.

The exports of wine in 1902 amounted to 4,801,492 gallons; in 1901 it was 2,786,607 gallons; in 1900, 6,559,810 gallons. The vintage of 1902 cannot be considered an average one, as many of the vineyards have been only recently replanted.

Jeres has several distilleries of spirits and liquors, and large cognac stills. Brandy is prepared according to the Charente method, and, being of good quality and cheaper than French cognac, it is rapidly taking the lead in popular consumption.

An important industry of Jeres is cooperage. The oak staves all come from the United States and are mostly shipped from New Orleans. One firm alone last year imported 175,000,000 staves. The hoop iron for casks is mostly purchased in England. The Jeres butts are famous for their solidity and fine appearance and are eagerly sought for by whisky distillers of all countries.

In the vicinity of Jeres several sulphur mines have been uncovered. The ore is rich and gives a high percentage of sulphur after its first fusion; it is said to be better than the Sicilian product. The proprietors of these mines are now seeking capital to exploit their property on a large scale. Buyers from abroad have contracted for large yearly purchases. There is a favorable opening for American capital.—M. M. Price, Commercial Agent at Jeres de la Frontera.

INDEX TO ADVANCE SHEETS OF CONSULAR REPORTS.

The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

SELECTED FORMULÆ.

Bottle-Sealing Materials.—What is commonly known as bottle wax is made by melting together ordinary rosin and beeswax, a little Venetian red being usually added to color it. The proportions of rosin and wax are about 15 to 2; some variation is required for climate. Burgundy pitch may be added to give a tougher wax, the proportions then being rosin 12, wax 2, and pitch 2.

When prepared to be sold to the general public the wax is usually molded into square "sticks." The molds may be open pans of tinned iron, which should be "chilled" by surrounding with ice cold water just before pouring the wax. The pouring should be done when the mixture has been allowed to cool nearly to the "setting" point and it should be well stirred as it nears this point and until pouring to prevent separation of the ingredients.

A finer kind of sealing wax may be made by the following formula:

Shellac	25 parts
Rosin	45 parts
Venice turpentine	15 parts

Color by the addition of Venetian red or ultramarine, etc.

A transparent red coating for cork tops and for sealing bottles is made as follows:

Select a clear sample of gelatin; to 3 parts of it add 9 parts of water, let soak until the gelatin is softened, liquefy by gently heating, and add 2 parts of glycerin, and enough cochineal coloring, N. F., to impart the desired tint.

The liquid must be kept warm for use, as it solidifies on cooling.

It may be necessary to slightly vary the proportions given to secure the exact result which is wanted.

Any coloring matter desired can, of course, be used; by soluble colors like cochineal coloring a transparent coating will be had, and insoluble ones, of course, give an opaque coating.

While the glycerin has a certain preservative power, it may be best not to prepare the solution in greater quantity than is required for early use.

Care must be taken to have the surface to be coated entirely free from grease.

The cap may be stamped while still soft with a slightly oiled die.—Drug. Circ. and Chem. Gaz.

Paste to Affix Labels to Tin.—Various experimenters hold that excessive dryness is the cause of separation of various mucilages from tin (and probably other metals). To obviate such dryness it is recommended to put a little calcium chloride in the paste, or some glycerin.

The following formulas have given satisfaction to many readers:

I.

Tragacanth	1 ounce
Acacia	4 ounces
Thymol	15 grains
Glycerin	4 ounces
Water, sufficient to make	2 parts

Dissolve the gums in 1 pint of water, strain and add the glycerin, in which the thymol is suspended; shake well and add sufficient water to make two pints. This separates on standing, but a single shake mixes it sufficiently for use.

II.

Rye flour	8 ounces
Powdered acacia	1 ounce
Glycerin	2 ounces
Oil of cloves	40 drops
Water, a sufficient quantity.	

Rub the rye flour and acacia to a smooth paste with 8 ounces of cold water; strain through cheese cloth, and pour into 1 pint of boiling water, and continue the heat until as thick as desired. When nearly cold add the glycerin and oil of cloves.

Perhaps a paste made from flour alone or from dextrin would answer, with the addition of glycerin.

For use on glass we have found a mucilage made from tragacanth alone very efficient.—Drug. Circ. and Chem. Gaz.

Perfumed Ammonia Water.—The following are typical formulas:

I.

Stronger water of ammonia	6 ounces
Lavender water	1 ounce
Soft soap	10 grains
Water, enough to make	16 ounces

II.

Soft soap	1 ounce
Borax	2 drachms
Cologne water	½ ounce
Stronger water of ammonia	5½ ounces
Water, enough to make	12 ounces

Rub up the soap and borax with water until dissolved, strain and add the other ingredients. The perfumes may be varied to suit the price.—Drug. Circ. and Chem. Gaz.

Sachet.—

Lavender flowers	8 ounces
Rose petals	8 ounces
Ground orris root	2 ounces
Ground benzoin	1 ounce
Oil of rose	10 minims
Oil of sandalwood	10 minims
Lavender water	2 drachms

Mix the solids, dissolve the oils in the lavender water and spray over the solids, turning the latter over constantly.—Drug. Circ.

Starch Gloss.—

Powdered soap	1 part
Powdered talcum	3 parts

Apply the powder to the right side of the starched article by means of a flannel rag and iron in the usual way.—Drug. Circular.

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